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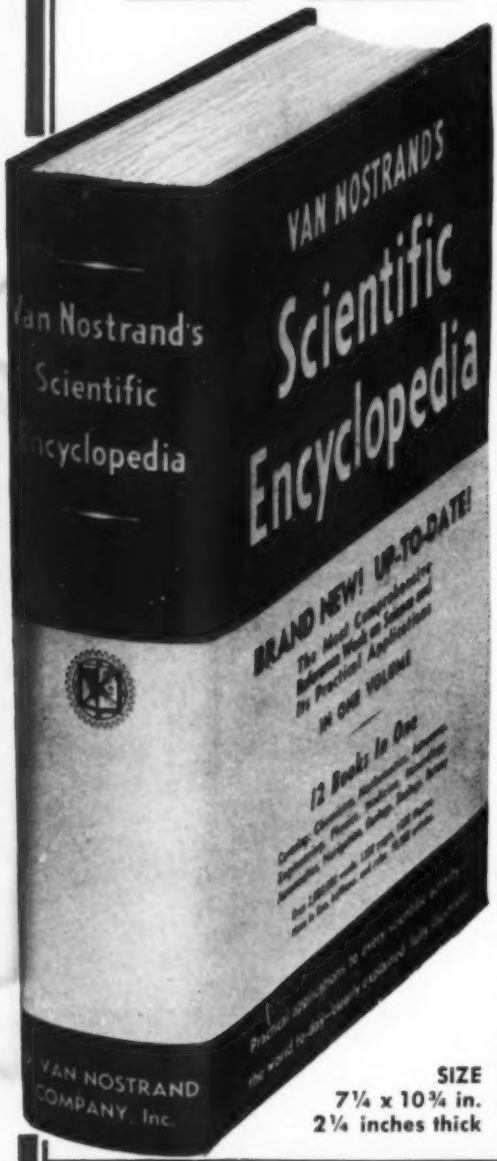

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Mechanics & Handicraft

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BRIG. GEN. ALDEN H. WAITT ("Smoke" Armor, page 62) is one of the few original World War chemical-warfare officers remaining in our Regular Army. Now Executive Officer of the Chemical Warfare Service, he is a frequent contributor to Popular Science Monthly and The Infantry Journal. His book "Gas Warfare" is accepted as the standard work on its subject.

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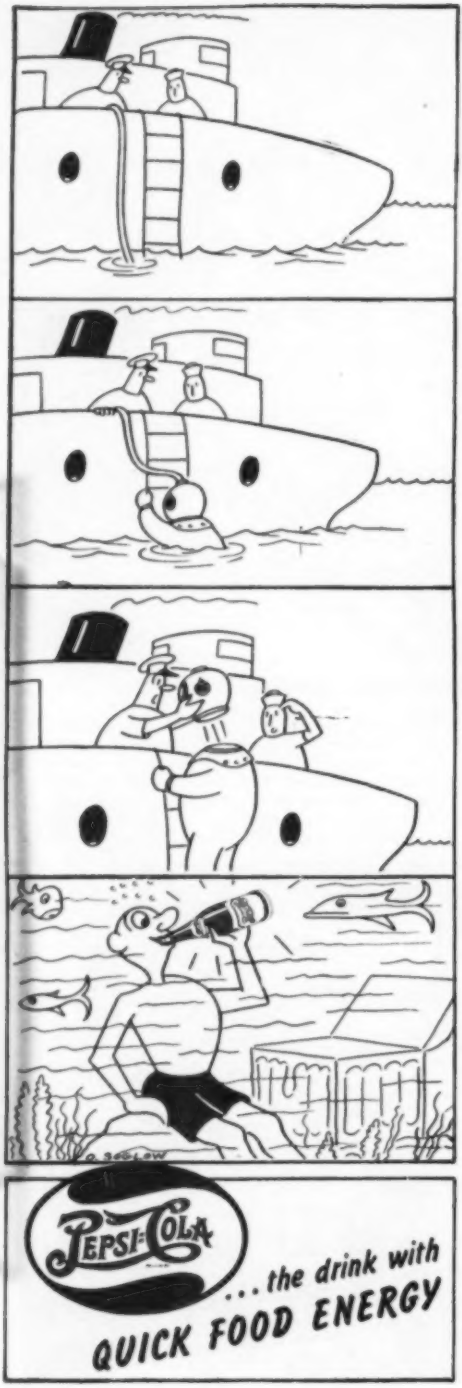

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FEAR is nothing to be ashamed of. Everybody at times has that sinking feeling in the pit of the stomach. It's what you do about it that counts. The Army, faced by the job of conditioning millions of men for the change from peaceful pursuits to the terrors of the battlefield, has discovered some interesting facts about fear and the way to control it.

PAINTING BIRDS from life is a fascinating art, whether you are a professional or an amateur. George M. Sutton, whose life portraits of American wild birds are prized by outdoorsmen and scientific naturalists alike, gives a step-by-step description of his working methods, from the sketching of the elusive model in the field to the making of the finished painting.

SHAPERS—small planing machines that deliver a short, forward cutting stroke—are finding increasing use in factories and shops. For the benefit of readers who want to master this handy machine, or are curious as to how it works, we publish a series of photographs from a film produced by the U. S. Office of Education for training of machine-tool operators.

FIGHTER PLANES engage in the fastest, deadliest form of combat known to man. Yet, even here, teamwork and tactics are the price of survival. Catch-as-catch-can dogfights between lone-wolf flyers belong in the movies. Drawings show how fighter formations maneuver to meet changing conditions in split-second combats miles above the earth.

WHAT ABOUT AIRCRAFT CARRIERS? The flat-tops got their baptism of fire in the present war. Previously untried in actual combat, they found themselves doing things for which they had never been intended. What has the war taught us about this highly specialized type of naval vessel? How will the lessons of battle affect their future design and use? Alden P. Armagnac gives the answers in an authoritative article.

SUMMER IS HERE! You can dodge a lot of the heat—and the humidity, too—if you will take a little trouble to give air circulation a chance in your home. J. Harold Hawkins, author of "Your House," makes practical suggestions for the job. You don't have to be an air-conditioning engineer to carry them out, either.

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Jobs Like These Go To Many Men I Train

There's a big shortage of capable Radio Technicians and Operators because so many have joined the Army and Navy. Fixing Radios pays better now than for years. With new Radios out of production, fixing old sets, which were formerly traded in, adds greatly to the normal number of servicing jobs.

Broadcasting Stations, Aviation and Police Radio, Ship Radio and other communications branches are scrambling for Operators and Technicians to replace men who are leaving. You may never see a time again when it will be so easy to get started in this fascinating field. The Government, too, needs hundreds of competent civilian and enlisted Radio men and women. Radio factories, with huge war orders to fill, have been advertising for trained personnel. And think of the NEW jobs Television, Frequency Modulation, Electronics and other Radio developments will open after the war! This is the sort of opportunity you shouldn't pass up

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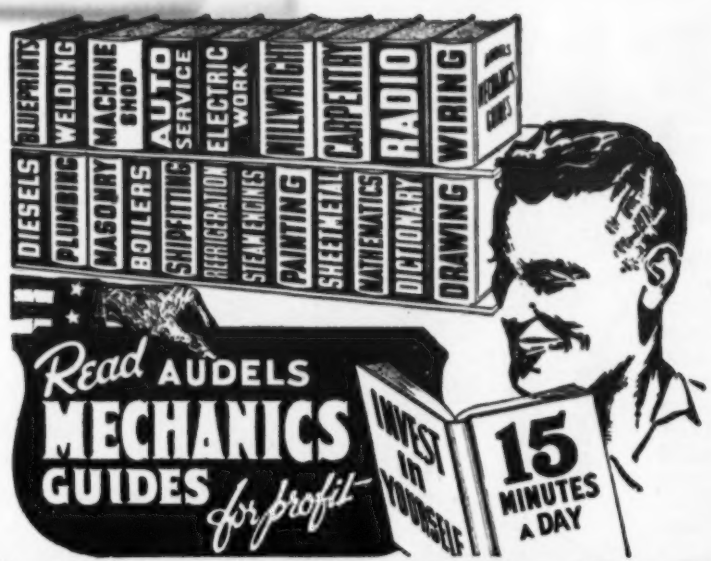

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Readers Say:

P. S. M. Canteens Go Over the Top Down Under

AS PRESIDENT of the Long Beach Homecrafters, of California, I think you might be interested in the following excerpt from a letter I recently received from Australia. "We would like to thank you and your Homecrafters for the excellent plans showing how to build canteen equipment which were published in POPULAR SCIENCE MONTHLY for December, 1942. We also wish to thank your splendid men and women, stationed here, for their timely help. We are sincerely grateful and try to make them feel at home among us. You can tell any American mother, father, sister, or brother that we are doing our best for the young men and women they have sent us. We treat them as our own children, inviting them to our suburban homes. Many of them have been taken into the Australian bush and they have seen your canteen equipment duplicated over and over again. They recognize it as an idea from the States and seem to enjoy food more when it is served from this equipment."—C. H. H., Long Beach, Calif.

This Is Why Editors Get Gray

I RECENTLY received my April copy of P. S. M., and found it very interesting. As I have been an electrical worker since 1929 I was naturally interested in the article "Battle of the Kilowatts." On page 109, however, what you describe as transformers look to me much more like oil circuit breakers. Am I right or wrong?—W. K. B., Clinton, Mass.

YOU'RE right, W. K. B., and we're both sorry and glad about it. Sorry that we made the error, and glad to be reminded that we have a critical and well-informed audience. Many thanks to you—and to our other readers who were sufficiently interested to write and call the mistake to our attention.—Ed.

"Murder!" He Says. Is This the Language of Science?

I FEEL like killing A. H. W., of Phoenix, Ariz., who wrote about piping air down from Pikes Peak for use in balloons, and also B. J. L., of Cleveland Heights, Ohio, who suggests compressing helium in tanks to make them lighter for air transportation. I also think the P. S. M. editor who allowed these letters to be published should be shot. These ideas are just too ridiculous, even if they are only "brainstorm entries." I have been reading P. S. M. for years and I enjoy it very much indeed.—A. J. G., New York, N. Y.

In Ohio the Problem Was Tougher

I AM writing in connection with the problem which R. S., of Akron, Ohio, had in your May issue. A man cashes a check for "X" dollars and "Y" cents at a bank. By mistake the teller gives him "Y" dollars and "X" cents. Without counting the money, the man goes to a hat store and buys and pays for a $3.50 hat. He then finds he has twice the amount of money that the check was originally drawn for. Question: what was the amount of the check? The answer is $14.32. But R. S. should have made it clear that the man knew where he could buy a hat without paying state sales tax—which, on this particular purchase, would have amounted to 11 cents, and which had me scratching my head a good deal longer than I needed to in order to solve the problem.—S. B., Cleveland, Ohio.

The Sergeants Are Good —But Not That Good

IN THE article "Army Gets High-Speed Film Processer" we note your statement that the processer develops 900 feet of film per minute. We believe this should be 900 feet per hour. We have worked this type of machine for well over a year, and the fastest developing we have been able to do is 825 feet an hour.—Sgts. I. B. L. and J. A. J., Army Air Forces, Eglin Field, Fla.

"HOUR" instead of "minute" is correct. We're sorry if we appeared to be rushing things.—Ed.

The light in a pilot's eyes

THERE'S something about a perfectly performing aircraft engine that makes a pilot's eyes shine. Unconsciously he is probably reflecting the confidence he places in it.

He undoubtedly does not think of its marvelously ingenious construction, the vital roles played by hundreds of precision parts each with its own specific job to do. No, to him it's one single mechanical marvel, with a distinct personality, which he has learned to know and respect because he has found it dependable in situations involving life or death.

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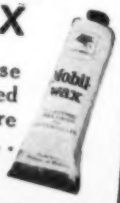

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Readers Say:

Hawaii Speaks —On V-Mail

I WOULD like to borrow few space in "Readers Say" department. It written in local papers that the V-mail is good to write home asking for money or other quick-needed item, but darn that V-mail its either too faint or too small of a letter, for a morale builder its no good to receive such a short and small letter, they rather receive a long letter from the friends and loved ones from home. Aloha.—P. M., Olaa, Hawaii.

Bed-Time Thoughts or the Earth's Rotation Might Explain It

I HAVE from time to time read various letters in "Readers Say" purporting to explain why it is that a dog makes several turns before lying down. Some say it is due to an instinct that goes all the way back to prehistoric times when animals of this size found it advisable, before lying down, to look around to see that no enemies were near. Others say that a dog makes these turns in order to "pat his bed." I think I have a better explanation. After a busy day of chasing autos, barking at the postman, treeing cats, and doing other helpful chores around the house, a dog prepares for his hard-earned rest with the thought, "Well, one good turn deserves another."—M. C. B., Bronx, N. Y.

IN CONNECTION with this discussion of why a dog makes several turns before lying down, I have noticed that my dog always turns counterclockwise. My theory is that the earth's rotation is responsible, as all whirlpools and revolving currents of air have a tendency to spin in this direction. If you don't believe it, watch the water leave the bath tub next Saturday night.—P. W. M., Whitinsville, Mass.

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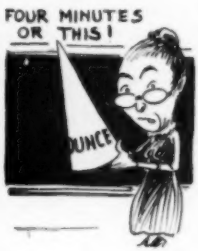

An Excellent Poem —But Who Wrote It?

IN THE article on how the U. S. trains its aerial gunners to be "Flying Sharpshooters," in your April issue, there appears on page 118 a poem titled "A Gunner's Vow." You may be interested to learn that this was written by a gunner in the Royal Canadian Air Force and was printed in our camp paper for August 7, of last year. The poem was given to us by a flight lieutenant who in turn received it from the author. Unfortunately, however, we used only the author's initials in publishing the poem, and then destroyed the original copy. His initials are G. H. H. We thought you might be interested to have even this meager information.—Group Captain A. R., Royal Canadian Air Force, Commanding No. 5 "M" Depot, Lachine, Quebec, Canada.

I HAVE noticed in your April issue that the poem "A Gunner's Vow" is said to be by an unknown author. The author is Pvt. Bernard Baker, of Limestone, N. Y. I am calling this to your attention because it is a good poem, and if it is worth printing at all I feel sure the author should get credit for it.—Mrs. L. D. F., Limestone, N. Y.

UNTIL *things clear up a little more, the poem is still anonymous.—Ed.*

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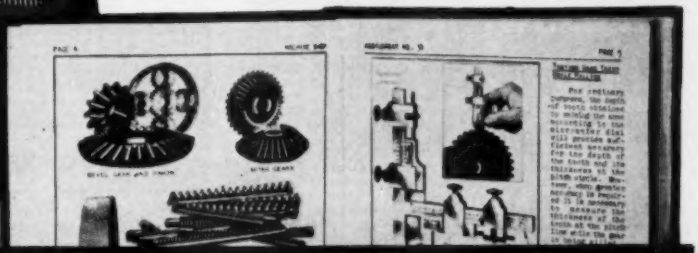

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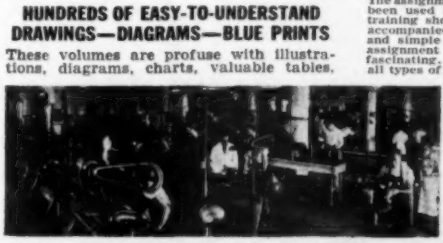

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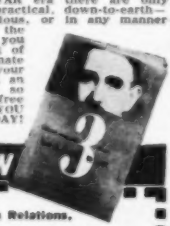

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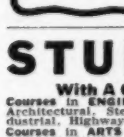

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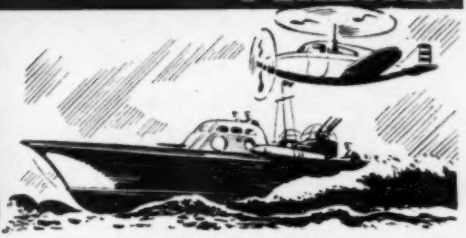

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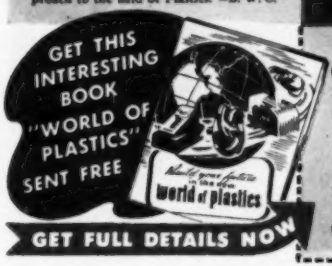

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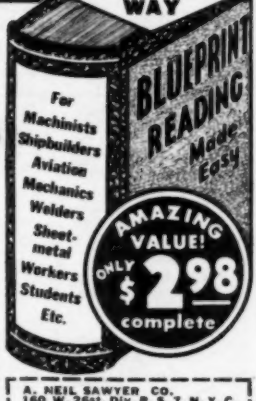

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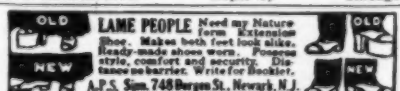
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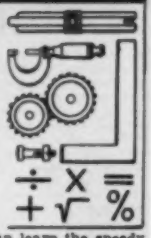

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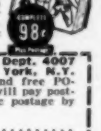

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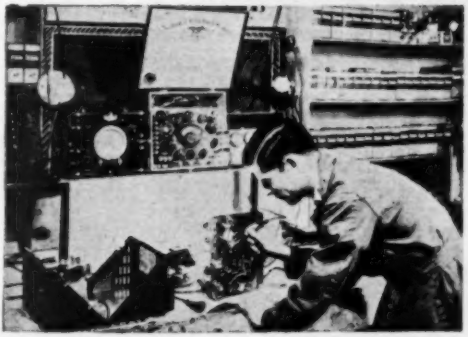

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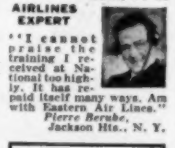

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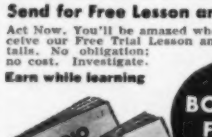

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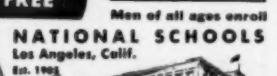

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U. S.—55 different, including airmails, commemoratives, etc., 3c. Approvals. Moseley, 4515 Laclede, St. Louis, Mo.

FREE!!! British Empire Packet. Postage 3c. Williams, 601 Archerbldg, Baycity, Mich.

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WANTED: Mercury (Quicksilver) $1.50 per pound. Western Metal Co., Bloomington, Illinois.

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NEW model electric welder 110 volt AC-DC; will weld all metals; easy to use; full directions. Complete with power unit, flame and metallic arc attachments, carbons, fluxes, rods, mask; all for $19.95—Used by the Navy. Marvel Electro Welder Mfg. Co., 195-AV Center St., New York City.

BUILD d.c. arcwelder without rewinding armature. Plans $1.00 each. 25 to 600 amperes from Vehicle motors. Light plant generators, Automobile starter-generators. Welders Club, WB-3432 M-Mart, Chicago.

WELD, Cut, Braze with gasoline! New discovery. Make your own torch. Instructions one American dollar. Matthews Mfg. Co., Calgary, Canada

"PERISCOPE ON THE STARBOARD QUARTER!"

IN SUBMARINE-infested waters, a speeding destroyer must be able to change its course in a split-second—to drop its deadly ashcans on enemy U-boats.

The secret of the destroyer's great *speed* and *maneuverability* is the tremendous power of its turbines, operating at steam temperatures *high enough to make the turbine blades glow!*

This introduces a difficult problem in turbine construction. The highly heated metal parts "creep" under stress. The metallic grains slowly slide over each other. The metal tends to *flow* out of shape.

Excessive "creep" would quickly destroy the turbine—due to collision between the blades and other parts of the turbine, which are spaced only a *fraction of an inch apart* for maximum power.

Westinghouse first introduced the steam turbine in the United States and has built thousands during the past 45 years. And much of the success of Westinghouse steam turbines is due to the intensive study of "creep" by scientists in the Westinghouse Research Laboratories.

As a result of the "know how" gained through this research, the "creep" in some turbine metals has been reduced to 1/10,000th of an inch per inch per year—less than 1/64th inch per inch in 100 years.

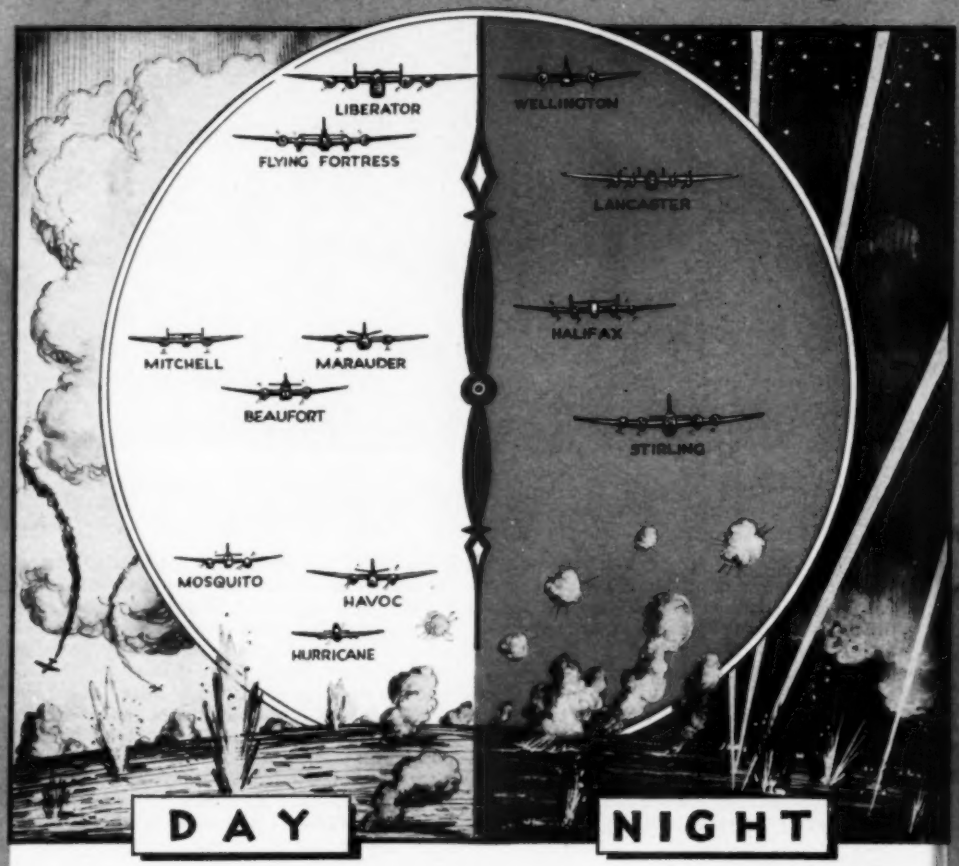
This has guided the development of metals capable of operating at greatly increased temperatures and speeds—and secured *more power per pound of turbine*, a vital necessity in a destroyer!

Westinghouse Electric & Manufacturing Co., Pittsburgh, Pennsylvania.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

"We shall bomb them by day and by night..."



Has Precision Bombing Failed?

By WILLIAM S. FRIEDMAN

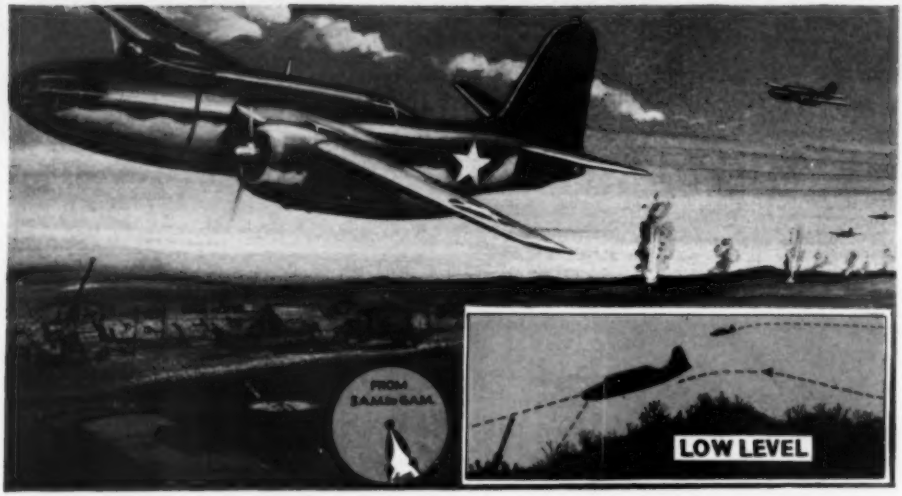
Drawings by Eric Sloane

THE day after a combined task force of Boeing Flying Fortresses and Consolidated Liberators put the German sub base at Vegesack out of action for a season, General Ira Eaker, commander of the Eighth U. S. Air Force, told American and British journalists that the experimental phase of high-altitude bombing had been concluded and that the business of crippling the Axis within its own preserves was beginning as of that day and in full earnest.

The facts that he made public made certain critics of daylight, high-altitude bombing in both England and the United States look very foolish. The high-flying Yankees had been feeling their way along slowly since last July. The force had been small and the outside opinion had been that the B-24 and B-17 class had been stymied in the British Isles, venturing out only on an occasional raid under nearly ideal conditions.

What the critics of the high-altitude, daybombing technique had failed to tell the public was that they were comparing the overall results of a full fleet of British four-en-

Out of the fog of uninformed criticism comes an authoritative appraisal of the part our Liberators and Fortresses are taking in the around-the-clock pounding that is softening up Hitler's European citadel.



EARLY MORNING is the best time for low-level attacks by light bombers such as the Douglas A-20 Havoc, and by bomb-carrying fighters. Radio locators can't pick them up at more than about 30 miles

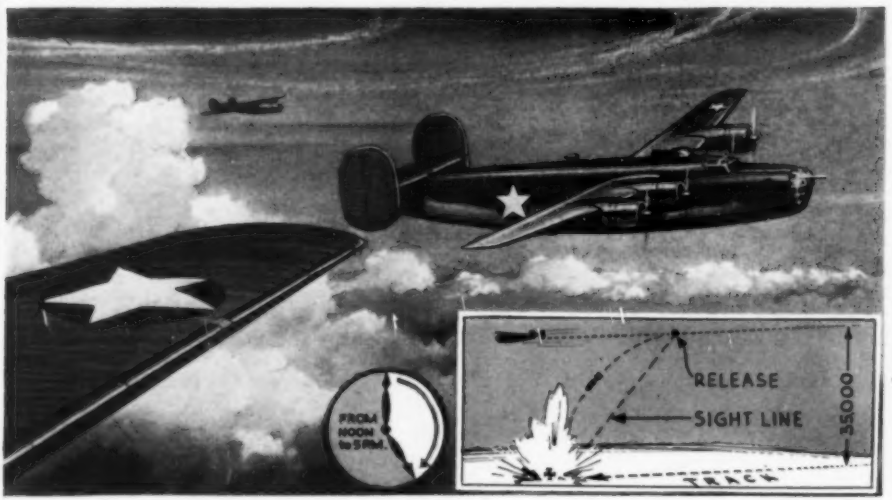
gined, all-altitude night bombers with a handful of our four-engined machines. Unfortunately, neither Britain nor the United States could have corrected this publicly up to this point without telling the enemy what they wanted to know about the disposition of aircraft.

Now that the score is about to be evened, facts concerning the relative merits of day and night bombing can be told.

Those who argue that one or another kind of bombing should be engaged in exclusively might well go back to military kindergarten. The basis for the United Nations system of bombing the Continent by day as well as by night is to saturate the enemy's defenses—keep him on guard without respite at all posts. Crews that man listening posts on the French north coast cannot be used to attack villages in Russia. Pilots who have to spend nights half awake in dispersal huts in the defenses of the Ruhr cannot be used in North Africa.

This projected system of keeping the enemy on constant alert requires all kinds of equipment, as no particular technique of at-

AFTERNOON, when the sun has dried the air, brings the Consolidated Liberators and Boeing Flying Fortresses for their precision work with the automatic bombsight, more than 70% accurate at 35,000 feet



SUNRISE TO NOON is most favorable for the two-engined mediums (North American Mitchell, Martin Marauder). They find a fairly safe level between the top of the light flak and fuse limit of big stuff

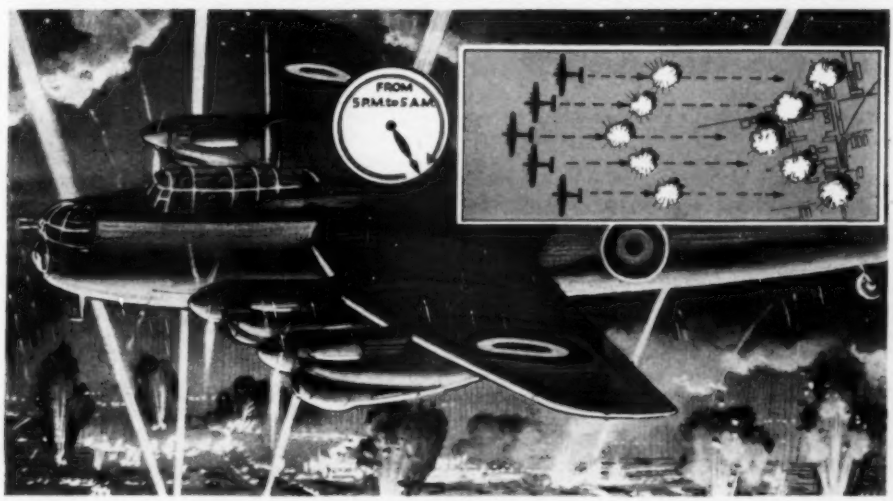
tack will answer for all purposes at all times.

There is an axiom among the commanders who man the flight deck of the unsinkable carrier which is England. It is that the day after 150 target areas in Germany and occupied Europe have been flattened will be the day of invasion. There are, however, a lot of things that have to be accomplished first. Expert estimates put the number of planes required to complete the job at 6,000 in the four-engined class—2,500 British heavies in the Halifax-Stirling-Lancaster class and 3,500 of our Liberators and Flying Fortresses. The modifying condition is that these ships shall complete their obliteration job in 90 days, so that all of these targets shall be out at the same time.

This prodigious job requires operation around the clock. Over-all 25% losses suffered by the British in daylight operations with heavies prove conclusively that flying these ships within the range of antiaircraft is an exorbitant expenditure of aircraft. That leaves the job of daylight bombing to aircraft capable of operating up out of the flak.

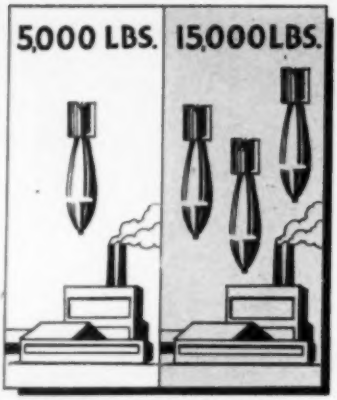
Daytime operation of our four-engined

NIGHT belongs to the British Lancasters, Stirlings, and Halifaxes, winged TNT trucks that blast whole areas with pattern bombing, dropping their four-ton block busters on signal from the formation leader



ships in the high-level zone stacks up perfectly with the classic Clausewitz principle of exposing one's strong point to the enemy's weak one. Our forte is high-altitude precision bombing. Our automatic bombsight has proved itself to be 70% accurate—better than most ordnance operating under the same conditions.

Consider the advantage it has over enemy ground installations. Once the ship has attained its service ceiling, it is practically immune to direct antiaircraft fire from the ground. Interceptor planes operating at that altitude have to struggle to stay on the wing. For the most part, the bombers are attacking a fixed target. They are sure that gravity will take their missile to the target level. Their job is merely to get the bomb onto the target. The poor antiaircraft gunner has to shoot against the pull of gravity at a target that is all but invisible, moving at 300 m.p.h.



It takes three times as much explosive to destroy a given target with "area" night bombing as with precision day work. Day bombers can pick out the vital spot; night raiders must cover the entire area with craters to accomplish the same mission

Any school of gunnery will teach a man that one blowgun that hits is better than a 16-inch cannon that misses. The precision bombers can hit what they want about three quarters of the time. Those who think that a near miss by a block buster is as good as a direct hit by a bomb a third its size should look at the target maps. Most of the things we need to destroy are heavily defended pinpoints. They have to be laid open by day and thoroughly crippled by precision daylight bombing, then obliterated by area bombing at night.

It should also be noted that night offers no immunity to the raider, either from antiaircraft or from defending planes. Airplane detection is an electronic, not a visual process, and detecting devices are mounted on defending aircraft as well as on the ground. Darkness merely cuts down the percentage—and not to any great degree, as indicated by the recent figures showing that daylight losses suffered by the Fortresses and Liberators were less per raid and about equal per ton of explosive carried over target than losses of the night-operated heavies.

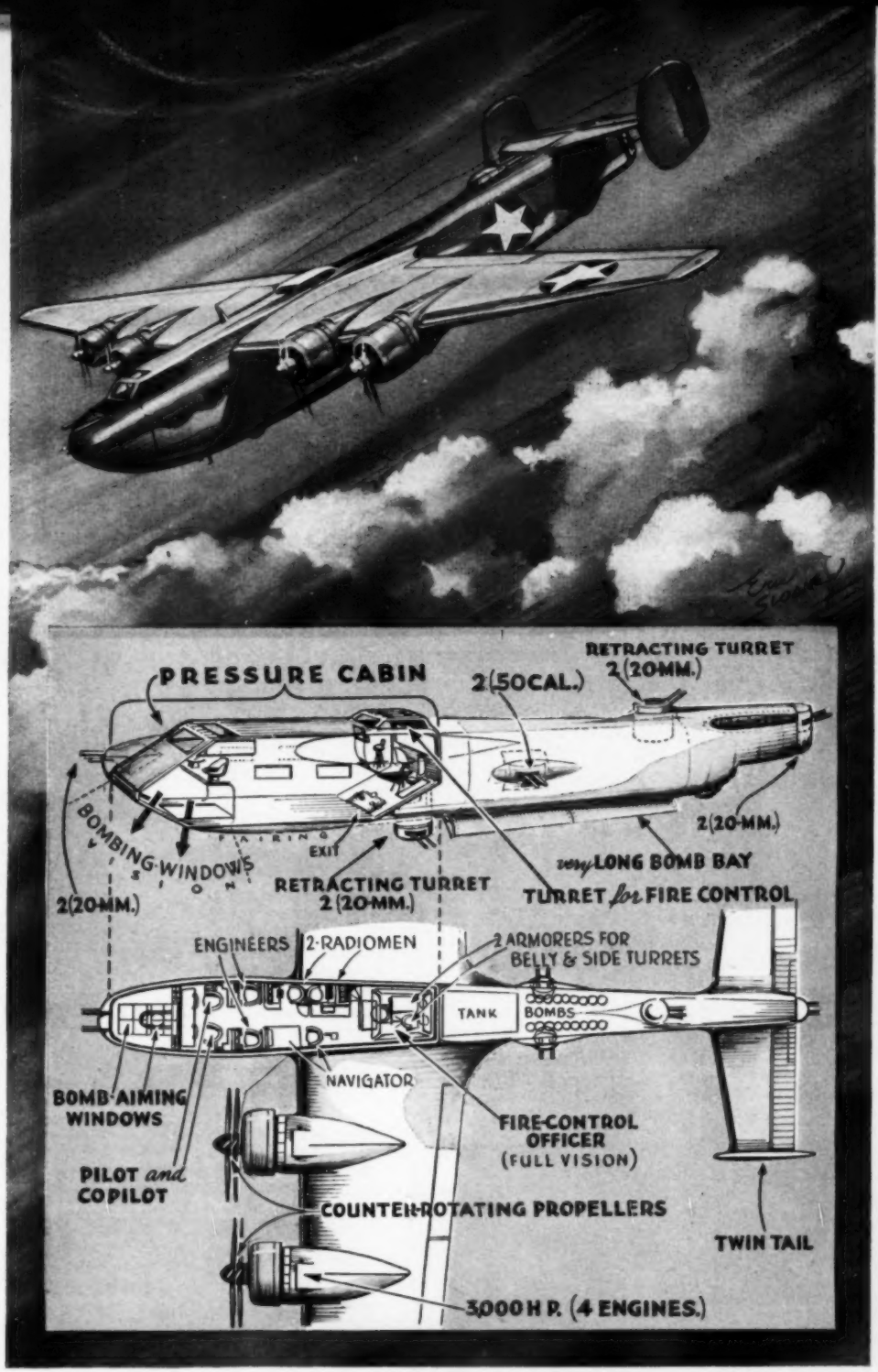
This is not meant to reflect on the Lancasters, Halifaxes, and Stirlings, but merely to indicate that no one type of bombing is the whole answer. Winston Churchill said, "We shall bomb them by day as well as by night." This takes a great variety of equipment and application.

While there are many phases of the problem of bombardment which may not be discussed publicly at this time—formations both offensive and defensive, and exact methods of sighting and operation—nevertheless, the general purpose and procedure and the equipment to be used by the United Nations are fairly plain. Contrary to some opinions, the ultimate plan is clear; the equipment is being mustered and placed on the flying line. The operations now in progress are, in effect, holding the enemy open for the inevitable "Sunday punch." When the time comes, it will mean hitting Hitler at all hours, in every weather, from altitudes of 50 feet to 40,000 feet, day and night and from all angles. The sleepless defenses, ready to snap under months of tension, will be only partly efficient. History will write the rest.

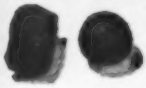
Starting from the ground, the low-level or zero-altitude bombing pokes rapier-like fingers at weak spots in the enemy's armor. All kinds of equipment take part in this type of operation. Douglas A-20's, the swift near-pursuit-speed Havocs, will sweep over the Channel at altitudes of 100 feet or less, carrying delayed-action bombs. Airplane-detection devices do not work with efficiency against minimum-altitude bombardment attack.

The low-altitude attack puts the defenders at another clear disadvantage. It is difficult to depress the antiaircraft guns to the shallow angle required to fire at this low, fast-moving target. Larger ordnance is useless, and the 20- and 40-mm. ground installations have a singularly bad record against this type of attack. Life for the low-level bomber crew is not all play, either. In the first place, navigation and target location are incredibly difficult. The terrain, at 100 feet at 300 m.p.h. is pretty blurred, and it can get very *(Continued on page 202)*

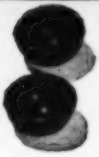
BOMBER OF THE FUTURE? No present-day bomber is a perfect all-around ship. No one can say just how tomorrow's planes will look, but here is an artist's conception of a "heavy" embodying features that seem to be dictated by experience to date


PRESSURE CABIN
2 (50 CAL.)
RETRACTING TURRET
2 (20 MM.)
2 (20 MM.)
BOMBING WINDOWS
FAIRING
EXIT
RETRACTING TURRET
2 (20 MM.)
2 (20 MM.)
very LONG BOMB BAY
TURRET for FIRE CONTROL
ENGINEERS
2 RADIOMEN
2 ARMORERS FOR
BELLY & SIDE TURRETS
TANK
BOMBS
NAVIGATOR
BOMB AIMING
WINDOWS
PILOT and
COPILOT
FIRE CONTROL
OFFICER
(FULL VISION)
COUNTER-ROTATING PROPELLERS
TWIN TAIL
3000 H.P. (4 ENGINES.)

MAKING THE CORE

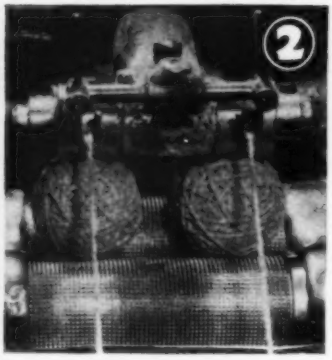


Cushioned cork, molded from ground cork and balata binder reclaimed from golf-ball covers, forms the center of baseballs now being used in the big leagues



These centers are then covered with balata shells, used in place of now unavailable rubber. Here the new inner shells are shown in the process of being pressure-molded in halves

Big Leagues Get a War



WINDING Coarse domestic wool is first wound by machine over the cores of the baseballs as shown above. There are four such windings, three of wool gradually increasing in fineness, and one of tightly wound cotton thread. Balls are next dipped in a cement to make the horsehide cover adhere to the cotton, and then given a careful inspection. At this stage they weigh 4⅛ ounces, measure 2 13/16 inches in diameter

NEW PROCESS SAVES RUBBER AND KEEPS OLD "PILL" LIVELY

Photographs by Robert F. Smith at A. G. Spalding & Bros. Plant

BATTED about the major-league parks after a lot of controversy as to its liveliness the new official ball is the result of much research for materials to replace Belgian horsehide, Australian wool, and all-important rubber. According to A. G. Spalding & Bros., who make all the baseballs used in both big leagues, the new balls are as lively and durable as any made in prewar years.

For core shells Spalding is using reclaimed balata, a South American gum of the rubber family, which, together with the cork center, produces a ball the equal in every respect of those used heretofore. Being similar to gutta-percha, balata has been used for years to make golf-ball covers. And while balata is still on the critical-materials list, no other use has been found for the balata that can be reclaimed from old golf balls. In replacement of the Australian wool and the Belgian hide that was formerly employed, Spalding is using domestic equivalents.

The two half shells of balata (a member of the rubber family) are fitted over the center by hand, above, and a cushion washer, also of balata, is inserted to hold the edges together

Another balata shell completes the core assembly. This one is made by pinching a strip of the gum over the inner shell and cushion washer, molding in a press, and then vulcanizing

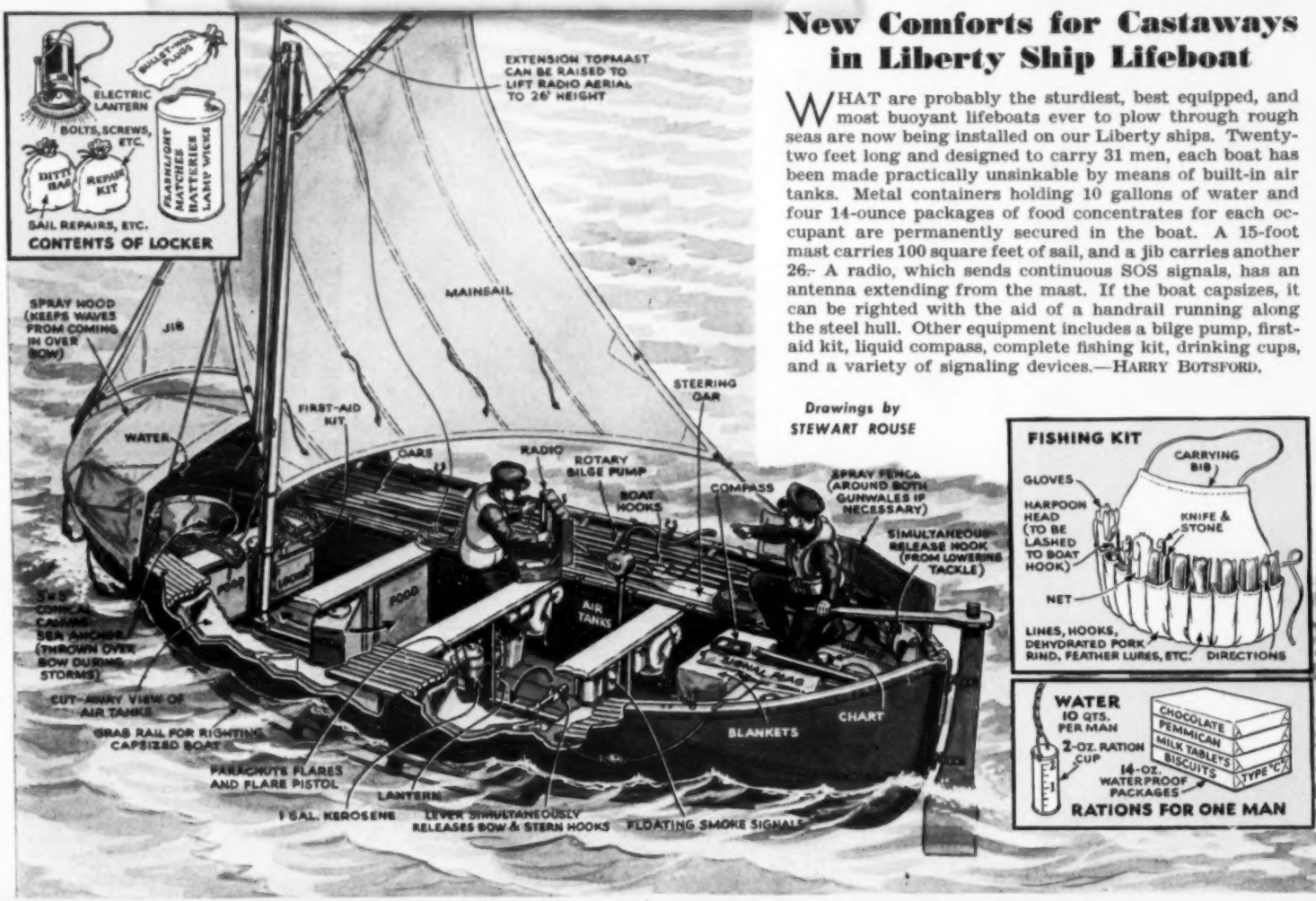
Baseball

COVERING One machine cuts the covers and makes perforations in them for stitches. Domestic horsehide takes the place of Belgian hide, formerly used for this purpose, but now another casualty of wartime shipping. The stitching is done by hand since no machine has yet been devised for the work. With the cover on, a ball weighs between five and 5¼ ounces and is nine to 9¼ inches in circumference. The step-by-step construction of the core and windings can be seen in the cut-away and cross-section views at right

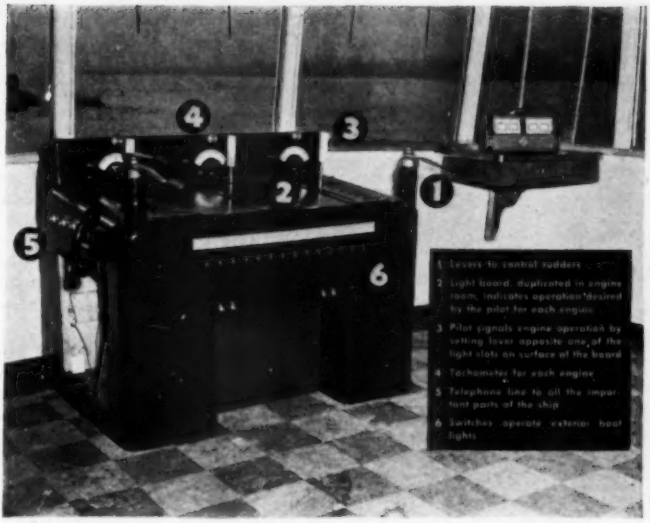
New Comforts for Castaways in Liberty Ship Lifeboat

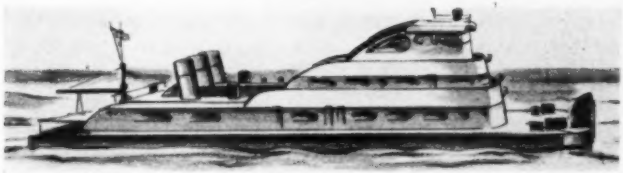
WHAT are probably the sturdiest, best equipped, and most buoyant lifeboats ever to plow through rough seas are now being installed on our Liberty ships. Twenty-two feet long and designed to carry 31 men, each boat has been made practically unsinkable by means of built-in air tanks. Metal containers holding 10 gallons of water and four 14-ounce packages of food concentrates for each occupant are permanently secured in the boat. A 15-foot mast carries 100 square feet of sail, and a jib carries another 26.- A radio, which sends continuous SOS signals, has an antenna extending from the mast. If the boat capsizes, it can be righted with the aid of a handrail running along the steel hull. Other equipment includes a bilge pump, first-aid kit, liquid compass, complete fishing kit, drinking cups, and a variety of signaling devices.—HARRY BOTSFORD.

Drawings by
STEWART ROUSE



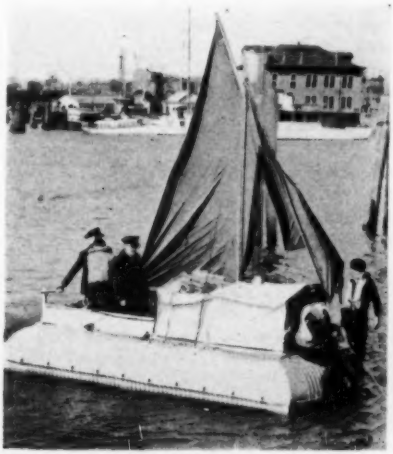
BOAT PILOTING is greatly expedited by the compactness of this control board installed on a Mississippi River tug. Most novel feature of the board is the light-signal system which conveys to the engine room the pilot's instructions on operation of the three engines. The pilot sets the white-handled levers opposite certain slots on the board's surface, which light up to indicate the desired operation—and then go out when the engine room has complied with the signals.


4
3
2
1
5
6
1 Levers to control rudders
2 Light board, duplicated in engine room, indicates operation desired by the pilot for each engine
3 Pilot signals engine operation by setting lever opposite one of the light slots on surface of the board
4 Tachometer for each engine
5 Telephone line to all the important parts of the ship
6 Switches operate exterior boat lights



The triple-screw "Sohioan," the Mississippi River towboat on which the new pilot board has been installed. The boat was built for the Standard Oil Co. of Ohio

A "SEASICKNESS" MACHINE has been developed by General Electric for laboratory testing of naval equipment under simulated seagoing conditions. Known as the Scorsby tester, the machine pitches and rolls in realistic style, and subjects the equipment being tested to all the ups and downs usually experienced by warships plowing through heavy seas.



"DE LUXE" LIFE RAFTS now being issued by the Navy are the last word in comfort for castaways. Fittings include portable mast and rigging, colored sails for better visibility, radio, smoke signals, and a canvas shelter for protection against the sun.

DID YOU KNOW THAT ROCKETS

Secret Rocket Weapons Blast

Buck Rogers' world comes true as warring powers devise self-propelled projectiles, fearsome-looking multiple launchers, and take-off boosters for aircraft.

By LEONARD ENGEL

ROCKET weapons, a genuine "secret development" of the present war, are playing an increasingly important rôle in military operations. Devices based on the rocket principle are in use to discharge projectiles, to trap and disable raiding aircraft, to increase the striking power of bombs, and to produce an extra take-off boost for planes carrying an overload of fuel or explosives.

It is a safe bet that every major military power is experimenting with rocket devices, although all of them regard the work as highly secret. Russia, Great Britain, and Germany are definitely known to have rocket arms in service, and the success of these weapons proves that the rocket principle has made a striking come-back from a position of relative scientific obscurity.

Rocket design has fascinated experimental scientists for centuries, and rocket weapons in war probably antedate guns themselves. But the rocket as a military arm went into a rather complete eclipse around the time of our Civil War. During the First World War, for instance, rockets were used only on a limited scale for signaling and other unspectacular purposes.

After the war, however, improvements in the design of casings and fuel led to a revival of interest in the rocket's military possibilities, and before 1939 it was known that most of the major armies of Europe were experimenting with the idea on a small scale. War speeded the process up in both the Axis and Allied camps, and now various types of arms based on the rocket principle are in use on many major battle fronts.

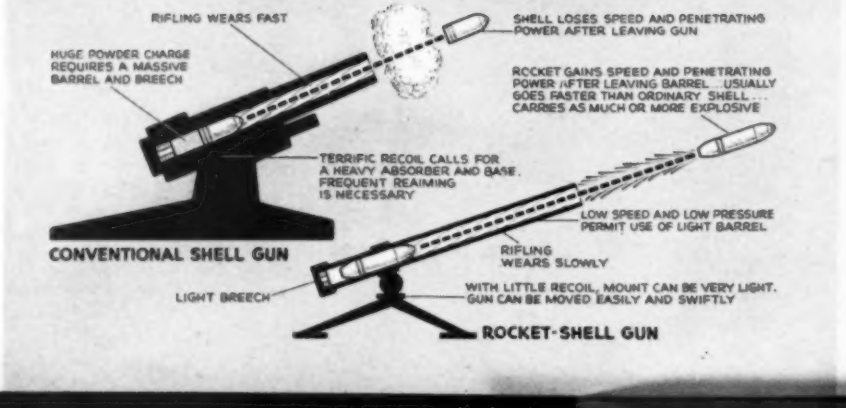
Although German propagandists, from Hitler down, have talked a lot about "secret weapons," the United Nations appear to have a commanding lead in this new phase of the armament race.

Since the summer of 1940 Britain has set aerial traps for low-flying planes with the PAC, a rocket device which carries aloft a parachute and a trailing steel cable. Another British weapon discharges ten explosive rockets simultaneously at raiding aircraft.

Soviet Russia uses at least four rocket arms: rocket bombs dropped by the Stormovik ground-attack planes; a rocket gun mounted aboard aircraft; a cable-trailing device similar to the British PAC, and a fearsome-looking instrument which can discharge 30 explosive rockets at a time at enemy tanks. The Germans are known to have two rocket weapons in use, a rocket bomb copied from the Russian model and a quick-firing rocket weapon, sometimes, apparently erroneously, referred to as a "mortar," with six 6-inch barrels.

Rockets have found other uses, notably in assisting planes to take off with heavy overloads or from cramped spaces. The RAF's Catafighter plane, carried on merchant ships as protection against long-range German bombers, is launched from the deck by rocket power rather than by a catapult.

HOW A ROCKET GUN DIFFERS FROM A REGULAR CANNON


RIFLING WEARS FAST
SHELL LOSES SPEED AND PENETRATING POWER AFTER LEAVING GUN
HUGE POWDER CHARGE REQUIRES A MASSIVE BARREL AND BREECH
ROCKET GAINS SPEED AND PENETRATING POWER AFTER LEAVING BARREL...USUALLY GOES FASTER THAN ORDINARY SHELL... CARRIES AS MUCH OR MORE EXPLOSIVE
TERRIFIC RECOIL CALLS FOR A HEAVY ABSORBER AND BASE. FREQUENT REAIMING IS NECESSARY
CONVENTIONAL SHELL GUN
LOW SPEED AND LOW PRESSURE PERMIT USE OF LIGHT BARREL
RIFLING WEARS SLOWLY
LIGHT BREECH
WITH LITTLE RECOIL, MOUNT CAN BE VERY LIGHT. GUN CAN BE MOVED EASILY AND SWIFTLY
ROCKET-SHELL GUN

HAVE COME BACK WITH A BANG IN WARFARE?

Tanks and Planes

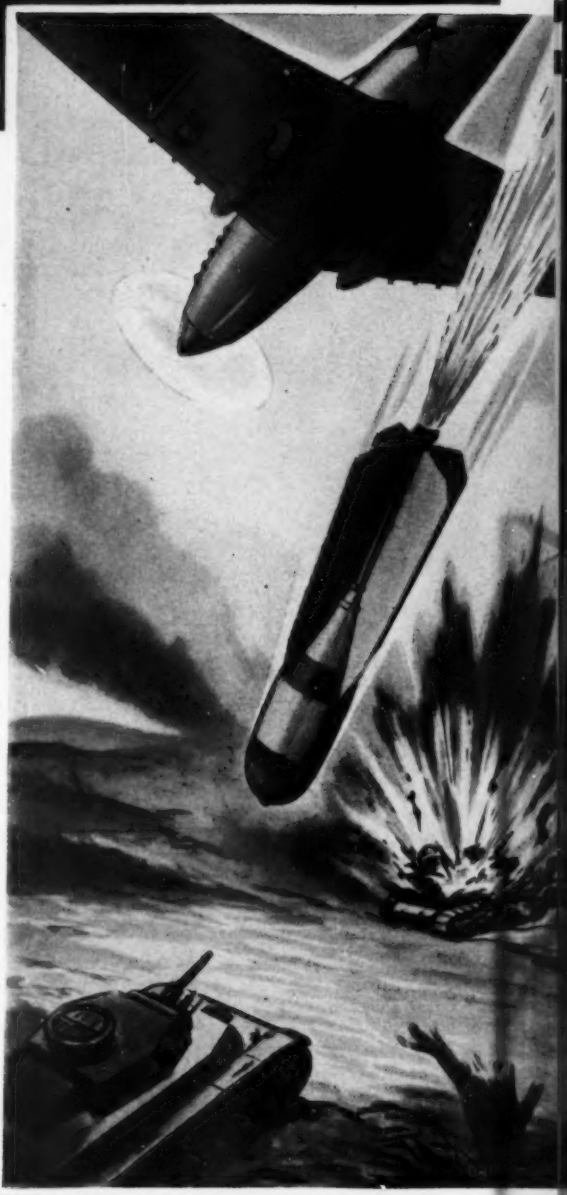
Rocket take-off boosters are used by the Nazi Luftwaffe on a small scale to help overloaded Junkers 88's and Heinkel 111-K's to get off the ground, and are in an advanced state of development in other air forces. In addition, the rocket principle, as applied to rocket-type engine-exhaust jets, is employed to add to the speed of several of the most recent pursuit planes.

The rocket obviously possesses an inherent advantage that no gun can match. Since it drives itself along, no extreme power explosion is needed to send it off, the tube or discharging mechanism is not called on to stand sudden violent pressure, nor is there a sharp recoil requiring elaborate compensating mechanism.

Therefore, rockets can be fired from lightweight tubes mounted on relatively flimsy firing platforms. As a result, such a weapon as the Russian 30-barreled gun, which would be an unworkable monstrosity in terms of regular artillery, becomes entirely practical. And rocket weapons provide the equivalent of heavy-caliber cannon mounted in airplanes, as well as portable "one-man" field artillery.

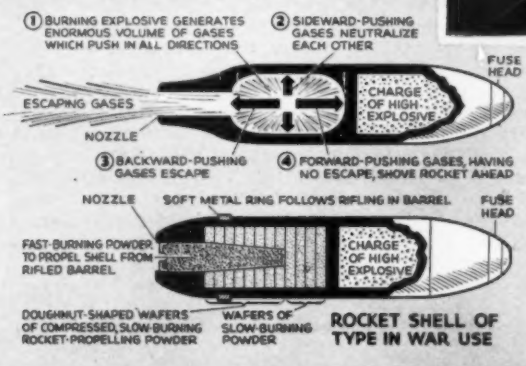
The rocket is one of the very oldest devices built upon the power of explosives. It was invented in China in the early part of the thirteenth century and introduced in Europe soon afterward, whereas the gun probably was not invented until the fourteenth century.

Nevertheless, the rocket as a military weapon has never enjoyed more than occasional popularity, mainly because it was more complicated to make and



ROCKET BOMBS dropped by Russian Stormovik fighter-bombers plow into tanks with armor-piercing force. Carried on rails under the wings, they are aimed by diving the plane at the target. When an electric spark sets off the propelling charge, the bomb slides off along the rails and seeks its mark in an almost straight line

WHAT MAKES A ROCKET GO


1 BURNING EXPLOSIVE GENERATES ENORMOUS VOLUME OF GASES WHICH PUSH IN ALL DIRECTIONS
2 SIDEWARD-PUSHING GASES NEUTRALIZE EACH OTHER
FUSE HEAD
ESCAPING GASES
CHARGE OF HIGH-EXPLOSIVE
NOZZLE
3 BACKWARD-PUSHING GASES ESCAPE
4 FORWARD-PUSHING GASES, HAVING NO ESCAPE, SHOVE ROCKET AHEAD
NOZZLE
SOFT METAL RING FOLLOWS RIFLING IN BARREL
FUSE HEAD
FAST-BURNING POWDER TO PROPEL SHELL FROM RIFLED BARREL
CHARGE OF HIGH EXPLOSIVE
DOUGHNUT-SHAPED WAFERS OF COMPRESSED, SLOW-BURNING ROCKET-PROPELLING POWDER
WAFERS OF SLOW-BURNING POWDER

ROCKET SHELL OF TYPE IN WAR USE

control than gun projectiles. And until now, at any rate, rocket projectors have been shorter-ranged and far less accurate than guns. The most notable historical success achieved with rockets was at the siege of Copenhagen in 1807, when Congreve rockets, developed in England during the Napoleonic Wars, were used to burn the city out and force its surrender. In that bombardment the rockets were used in much the same systematic way that a modern commander who had control of the air could use incendiary bombs to destroy an enemy city.

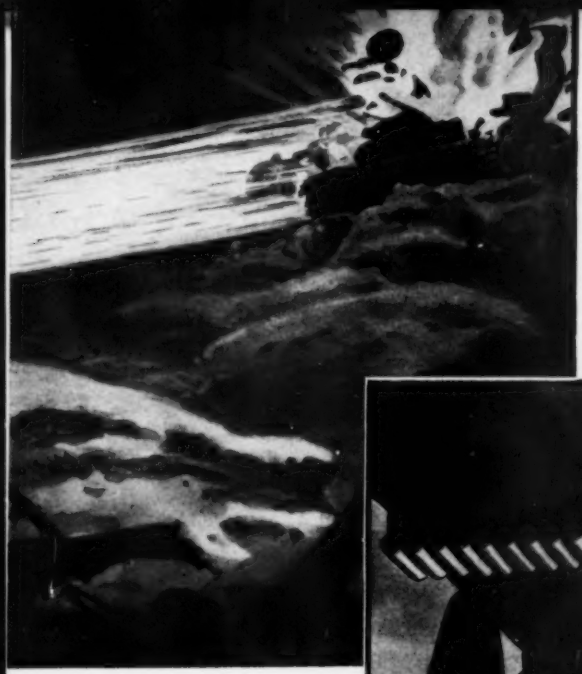
Rockets of today fall into two classes, solid-fuel and liquid-fuel. In either case, the fuel is a "lazy" explosive which drives the rocket by the reaction principle, akin to the firing and recoil of a gun. When the charge inside a rocket is fired, the gases generated exert equal pressure in all directions. Gases pressing backward, however, are permitted to escape by one or more nozzles. In a gun they escape by driving the bullet through the barrel. The only "escape" for the gases pressing forward in the rocket is to drive the rocket itself ahead. Similarly, the backward-pressing gases in a gun cause the gun to recoil.

The principal difference between a rocket and a gun is that action and reaction take place inside the projectile in the case of the rocket, and outside it in the case of the gun. The belief that the rocket is propelled by the "push" of the gas jet against the air is erroneous.

The military projectile rockets now in use are all of the solid-fuel type, like the traditional skyrocket. Liquid fuels do not lend themselves to preloading, an essential of operations on the battlefield.

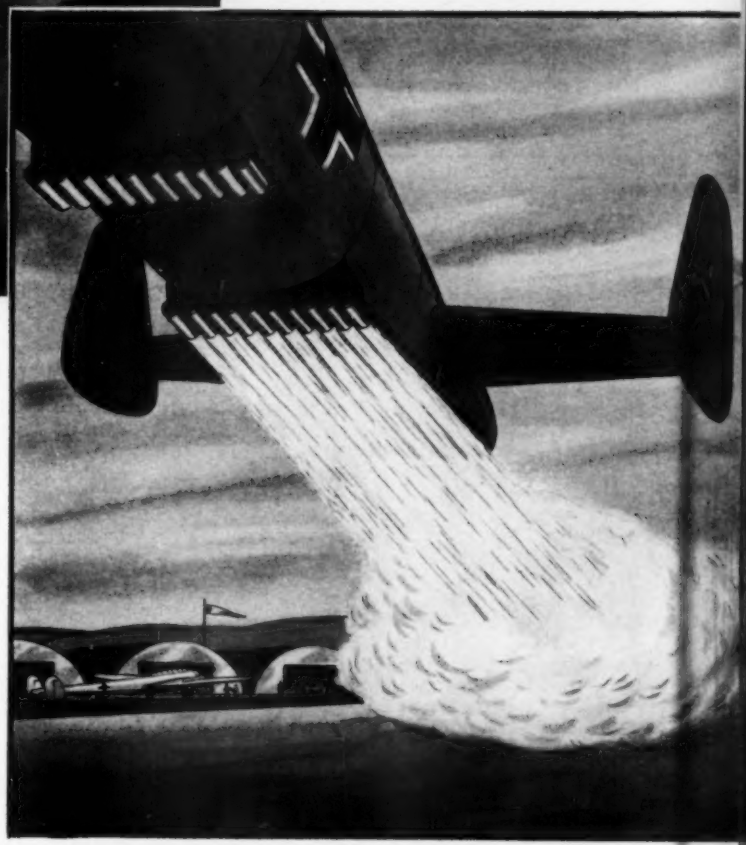
At least three solid explosives have been employed with success. England uses cordite with an admixture of starch as a "deterrent" to keep the burning rate within rocket limits. Prof. Robert H. Goddard, dean of American rocketry, carried out successful experiments with nitrocellulose (smokeless powder) fuel during the last war. And the German six-barreled weapon fires rockets powered with gunpowder. The German mortar weapon is packed with gunpowder wafers, solid wafers toward the head and doughnut wafers toward the tail, with loose powder filling the hole in the column of doughnuts. When fired, the loose powder flash-burns at once, producing a high initial thrust and acceleration.

As a general rule, rocket projectiles weigh about a third more than standard shells of the same caliber, for they must carry not only driving and bursting charges, but also the weight of the heavily reinforced combustion chamber, whereas the shell has to carry only a bursting charge. Even so, the shell would generally have the larger bursting charge. For example, a three-inch shell weighs 13 to 15 pounds and has a bursting charge of about two pounds of high explosive; a three-inch rocket would weigh perhaps 20 pounds, but its bursting charge would be little more than a pound.



MULTIPLE PROJECTORS, another Russian development, fire 20 or 30 shells at once. Scattering like shotgun pellets, the self-propelled projectiles make a pattern that a tank can hardly dodge. Such a weapon for ordinary shells would be much too heavy

TAKE-OFF ASSISTERS are employed by the Germans to help lift heavily loaded bombers off the ground. Rows of large rocket cartridges attached to the body of the plane are discharged at the right moment. After the take-off, the device is dropped



If smokeless powder is the fuel, rockets such as these can easily attain velocities of 2,000 feet per second in a mile of flight—greater than any but the very best high-velocity guns can deliver at that distance. The 20-pound rocket would require about eight pounds of nitrocellulose with a deterrent, or a six-pound charge if no deterrent were used, but then the time of combustion would be much shorter and the combustion chamber would have to be much heavier. Black powder, which has only half the power of smokeless, is not powerful enough to reach the 2,000-foot velocity, but it can reach 1,500 feet per second at a mile.

In view of the relative inaccuracy of rockets, a range of two miles is considered fairly long. The German weapon, however, by using a small rocket—50 pounds as compared with 95 pounds for the standard six-inch shell—and sacrificing much of the normal bursting charge, has an observed range of 6,000 yards (3½ miles).

Russia is the only nation known to have succeeded in taking advantage of the light weight and absence of recoil of rocket apparatus in order to place large-caliber weapons aboard planes. Such experiments, however, are unquestionably under way in other countries. The machine guns and light cannon which are now standard on aircraft are adequate for attacking other aircraft. But 37-mm. guns (the largest air cannon) are not powerful enough for attacking ground targets, a function of in-

creasing importance for planes. Larger guns of conventional type, however, are impractical because of their weight.

The rocket's inaccuracy has several causes. The most troublesome is the fact that no two fuel charges are exactly alike in burning rate, or time, or power delivered (thrust) from second to second. Even minor differences here make a considerable difference in the point where the rocket will land, because these differences are acting over a considerable period of time. Second, the center of gravity shifts as the fuel is consumed, changing the rocket's ballistic characteristics. Third, as long as the fuel lasts (from two to five seconds in most cases, the rocket traveling on its momentum the rest of the way just like a bullet), the ejected gases build up a high-pressure area immediately behind the rocket. Once the fuel is gone, however, the high-pressure area is replaced by the partial vacuum which follows the ordinary projectile. Naturally, this change has a decided effect on the trajectory.

Some day, perhaps soon, rocket charges will be identical and scientists will be able to work out correction tables for the other factors. Then the rocket will be as accurate as the gun. But in the meantime "cluster" weapons, such as the German weapon, the Soviet antitank "battery," and the English AA rocket device, are effective. Precision of fire is hardly required to hit even a rapidly moving tank with one or more of the 30 rockets the Soviet weapon discharges.

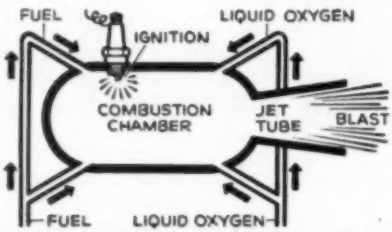
Inaccurate as it is, the rocket has already added measurably to the accuracy of one arm—the ground-attack bombers. The oldest of the current series of rocket devices, aside from PAC, is the rocket bomb. Stormovik planes used them effectively in November 1941 to help repulse the final Nazi assault on Moscow.

The rocket bomb is nothing more than an ordinary bomb with a small combustion chamber and charge in its tail. The purpose is to add to the bomb's velocity, thereby increasing its impact and penetrating power, which vary as the *square* of the velocity, and adding to the bombardier's accuracy by flattening the bomb's trajectory and cutting its flight time. The first Russian rocket bomb, a 220-pounder, accomplished this purpose with an 11-pound charge of black powder fired in a combustion chamber weighing about 25 pounds.

Dropped from a plane traveling at 200 miles an hour at 1,000 feet, a conventional 220-pound bomb will reach its target in three seconds with an impact velocity of about 375 feet per second. One of the Soviet missiles, however, would reach the target in 2.1 seconds with a velocity of more than 650 feet per second, and with impact more than three times as great. The rocket bomb would require an unnecessarily large charge to exceed the terminal velocity of the free-falling bomb (about 900 feet per second); hence, it is not used for high-altitude bombs. But it doubles the effectiveness of the dive bomber and ground-attack craft.

In the years between this and the last war, rocket experiments were carried on principally by private individuals. Later some of these men banded together in national societies, of which the German Rocket Society, founded 1927, the oldest, and the American Rocket Society are the best known. By and large, they were not interested in rocket projectiles. Their attention was centered rather on high-altitude rocket flight, with passenger-carrying stratoships and even interplanetary "space ships" as their ultimate goals. Since solid fuels proved unsuited to their objects, they began to develop liquid fuels, notably the liquid oxygen-gasoline (pioneered by Dr. Goddard) and liquid oxygen-alcohol. Although neither will ever send a space ship to the moon or even from New York to Berlin, they will undoubtedly be of great use in the near future in sending aloft meteorological rockets, one of the most important potential uses of the rocket. They also have great possibilities for assisted take-offs in commercial-airline operations. Even before the war began, considerable work along this line had been done. In most countries, the favored practice was to build the fuel tanks, combustion chamber, and nozzles into the trailing edge of the aircraft's wings.

Liquid-oxygen fuels, however, are impractical for military operations. Germany has abandoned the liquid-fuel idea altogether for the time being.



SIMPLE ROCKET MOTOR OPERATING ON LIQUID FUEL AND LIQUID OXYGEN. FASTENED UNDER WINGS OR FUSELAGE OF PLANE, IT CAN BE USED TO ASSIST TAKE-OFFS OR FOR BURSTS OF SPEED IN COMBAT

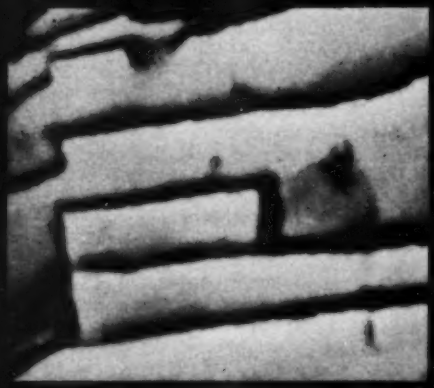
ROCKET MOTORS have great possibilities as take-off assisters for planes, and also for boosting speed in air fighting. This is our artist's conception of such a motor's design

Superthin Films Show Surface Structures

FINE glasslike films of less than .000002-inch thickness have now been developed to provide faithful replicas of the microscopic structures of metal and other opaque surfaces for study with the electron microscope. They are evaporated onto matrices of polystyrene plastic which have been molded under 2,000 to 3,000 pounds pressure.

This unique method of electron micrography is the result of research by scientists for The Dow Chemical Company, of Midland, Mich., who sought an improvement over the use of natural surface films produced chemically, and plastic-lacquer films that were apt to smooth out because of surface tension and contraction. They found polystyrene ideal for taking negative impressions beause of its dimensional stability, chemical inertness, and moldability. A matrix of this plastic is placed in an evaporation chamber where high-purity silica is evaporated on it from a hot filament. When hardened, the silica film, bearing the positive impression, is removed by the use of ethyl bromide solvent.

Electron micrograph at 15,000 diameters of a piece of steel scratched by levigated alumina on a chamois wheel. The grooves appear light



Polished and etched steel taken at 25,000 diameters. This three-dimensional effect shows the formation of pearlitic structure

Plane of cleavage of a calcite crystal that was deformed during molding. Glide packets can be seen clearly here at 15,000 diameters

Another view of the etched steel at 8,000 diameters. These are plastic-silica electron micrographs made by The Dow Chemical Co.

These Are the Badges of Courage

Our soldiers and sailors now may win seventeen new decorations and service medals—all adopted since the war emergency. Popular Science Monthly presents these new honors, and the principal older ones.

By BERNARD WOLF

Photographs by ROBERT F. SMITH

IN THE eventful months since Sept. 8, 1939, when President Roosevelt declared a state of national emergency to exist, no less than 17 new medals and ribbons have been authorized for award by the President or high officials of the armed forces. Today service men, many of them back from combat duty in foreign theaters of war, are beginning to appear on the streets of our towns and cities with bright new ribbons displayed on their chests, each one of them telling a story about its wearer, if you can interpret its meaning.

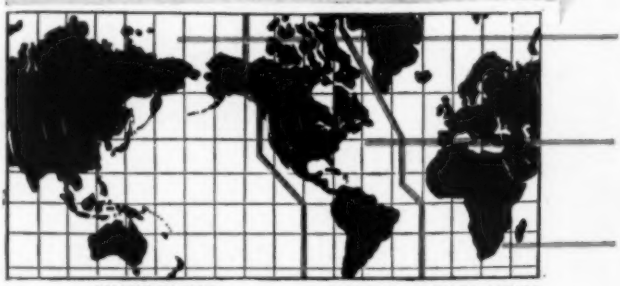
Two of the new decorations—the Legion of Merit and the Air Medal—were created for the personnel of both armed services. The Legion of Merit will also be given to the military personnel of friendly foreign nations. A series of service medals, including the American Defense Service Medal, the Army of Occupation of Germany (1918-1923) Medal, and the campaign medals for the three theaters of the global war—American, European-African-Middle Eastern, and Asiatic-Pacific—was also designed for both the Army and the Navy. Further, the Navy adopted for its own use two established Army decorations, the Silver Star and the Purple Heart, and authorized one new medal, the Navy and Marine Corps Medal (design not yet approved) for its own branches. The Army established a Good Conduct Medal to round out its list of awards for its own personnel.

Finally, Congress authorized a Medal for Merit (design not yet approved) as the civilian counterpart of the Legion of Merit and, for the first time in history, two more awards intended specifically for merchant seamen, the Merchant Marine Distinguished Service Medal and the Torpedoed Seaman Bar. Two other unique awards have also been set up recently: the Army's Organization Blue Unit Citation and the Navy's Presidential Unit Citation, each a ribbon which denotes that the wearer belongs to some unit of the armed forces which has been twice cited by the President. These devices approximate in function the Fourragère, the famous braided shoulder cord awarded by the French to members of all U. S. Army organizations cited in World War I.

The marks of honor worn by members of our armed forces fall into two chief categories. *Decorations*, properly speaking, are awards for outstanding heroism or valor, both combat and noncombat, or for extremely valuable and meritorious service. *Service medals*, on the other hand, are intended to show that the recipients have participated in particular campaigns, whatever their rôles may have been. In order to conserve critical metals, several of the new medals will not be issued for the duration, only the appropriate ribbons being given.

Some of the new decorations and service medals represent radical departures from tradition. The Legion of Merit, for example, is the first medal issued in different rankings. It has been designed in four degrees —those of Chief Commander, Commander, Officer, and Legionnaire.

Can you identify these medals and ribbons? Every one on this page was issued since 1939. Following pages show older decorations.

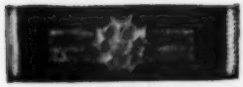


ASIATIC-PACIFIC THEATER

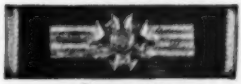
AMERICAN THEATER

EUROPE-AFRICA MIDDLE EAST

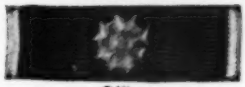
NEW MEDALS



Chief Commander



Commander

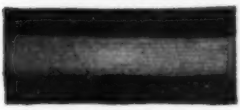


Officer

LEGION OF MERIT. Will be awarded to personnel of U. S. and friendly foreign armed forces for outstanding service. Shown at the left is Legionnaire medal; higher degrees are larger in size. Except on dress occasions, ribbons (above) are worn in place of medals.

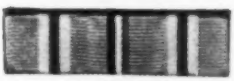
MEDAL FOR MERIT. For civilians of United Nations and friendly powers. Only the ribbon has been issued.

Navy and Marine Corps Medal, for which only the ribbon has been issued. For heroism not involving combat.



Presidential Unit Citation, for Navy units twice cited. An American counterpart of the French fourragère.

Organization Blue Unit Citation, for Army units twice cited for outstanding performance of duty in action.



Asiatic-Pacific

American

Europe-Africa-Middle East

Theater Campaign Medals indicate presence on active duty. Bronze star means one engagement – silver, five.

ARMY OF OCCUPATION OF GERMANY. For service in occupation after World War I.

AIR MEDAL. For achievement not meriting the Distinguished Flying Cross. Any branch of armed services.

GOOD CONDUCT. For Army enlisted men who complete three years of active service and are recommended.

AMERICAN DEFENSE. For active service in Army or Navy between Sept. 8, 1939, and Dec. 7, 1941.

ARMY & NAVY DECORATIONS

HONORS

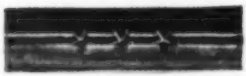
SILVER STAR. For gallantry in action while serving in any capacity. Instituted by the Army in 1932. Adopted by the Navy in 1942.

PURPLE HEART. For wound received in action. Revolutionary honor revived by Army in 1932; Navy, 1942.

CONGRESSIONAL MEDAL OF HONOR (1917-18). This version of the Navy's highest award, for gallantry in action, is no longer issued.

DISTINGUISHED FLYING CROSS. For heroism in the air. Limited to flyers of Army, Navy, and Marine Corps. Authorized in 1926.

MERCHANT MARINE Distinguished Service Medal. Authorized this year. For heroism on service in submarine-infested waters.



TORPEDOED SEAMAN BAR. For Merchant Marine personnel. One silver star for each torpedoing survived.

NAVY CROSS. Authorized in 1919 and ranking next to the Medal of Honor Goes to Navy, Marine Corps, and Coast Guard men for extraordinary heroism.

AND DECORATIONS OF THE NAVY

CONGRESSIONAL MEDAL OF HONOR. Highest award of the Navy. Established in 1861. For conspicuous gallantry and intrepidity.

MARINE CORPS BREVET MEDAL. Established 1921. For holders of commissions issued by the President and conferred by the Senate.

RIBBONS ARE WORN IN THIS ORDER

- Medal of Honor.
- Medal of Honor (1917-18).
- Marine Corps Brevet Medal.
- Navy Cross.
- Distinguished Service Medal.
- Silver Star Medal.
- Distinguished Flying Cross.
- Navy and Marine Corps Medal.
- Specially Meritorious Service Medal.
- Purple Heart Medal.
- Presidential Unit Citation.
- Legion of Merit (relative standing not fixed).
- Medal for Merit (relative standing not fixed).
- Army of Occupation of Germany (service medal).
- American Defense Service Medal.
- Theater Campaign Medals (in order as earned).

DISTINGUISHED SERVICE MEDAL. Established 1919. To any person, serving in any capacity, for meritorious service with the Navy.

SPECIALLY MERITORIOUS SERVICE MEDAL. For distinction in the war with Spain, other than in battle. No longer issued.

THESE ARE ARMY MEDALS

CONGRESSIONAL MEDAL OF HONOR. Army's highest decoration, established 1862. For conspicuous gallantry and intrepidity in combat beyond the call of duty.

DISTINGUISHED SERVICE MEDAL. Instituted in 1918. To members of Army, Navy, or Marine Corps for exceptionally meritorious service with the Army.

RANK OF DECORATIONS DETERMINES ORDER FOR WEARING RIBBONS

Ribbons worn in lieu of medals are arranged on the wearer's left breast, beginning at the right, in the order of precedence of the decorations. When more than one line is worn, the lines overlap. Service medals follow decorations in the order of the date of service, with the Good Conduct Medal worn on the left of all service medals. Oak Leaf Clusters, representing additional citations, are worn on the ribbons of the appropriate decorations; battle stars are affixed to service ribbons for the campaigns to which they pertain. While the rank of all decorations has not been finally determined, the following is accurate at present:

Medal of Honor.

Distinguished Service Cross.

Distinguished Service Medal.

Silver Star.

Purple Heart.

Soldier's Medal.

Distinguished Flying Cross.

Legion of Merit.

Medal for Merit.

Air Medal.

Organization Blue Unit Citation.

Army of Occupation of Germany (service medal).

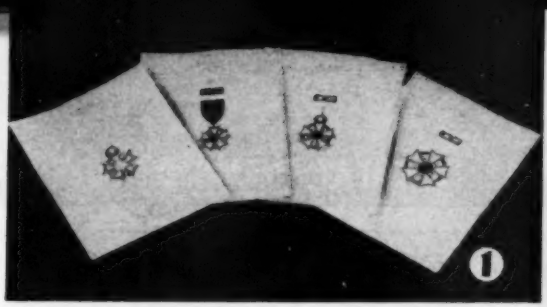
American Defense Service Medal.

Theater Campaign Medals.

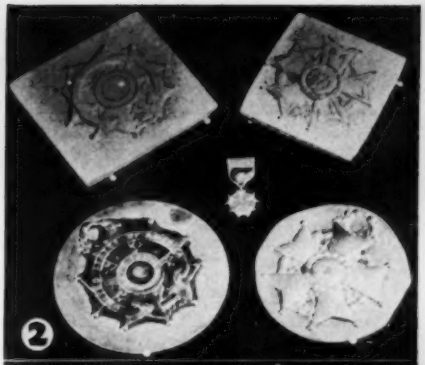
Good Conduct Medal.

DISTINGUISHED SERVICE CROSS. Instituted in 1918. Awarded for extraordinary heroism in operations against an armed enemy, to any person serving with the Army.

SOLDIER'S MEDAL. Instituted in 1926. Awarded to personnel of Army, Navy, and Marine Corps for heroism not involving conflict while serving with the Army.



1 Making a medal begins with a water color of its design. The sketches above show various degrees in which the Legion of Merit is issued. Wax forms are then modeled



2 Plaster patterns (top), made from the wax forms, are placed in an electroplating bath to produce galvanos, or metal plates (below). Actual-size medal is in center

3 Obverse and reverse designs are reduced to steel hubs from which these female dies are made. Blank is then repeatedly struck between dies under 300-pound pressure

How Medals Are Made

Photographs by Robert F. Smith

THE manufacture of medals, such as those shown on the preceding pages, is an interesting story in itself. These photographs, taken at the Philadelphia plant of Bailey, Banks and Biddle, silversmiths and medalists, show the production of the Legionnaire rank of the Legion of Merit (page 57). The higher degrees of this decoration —Chief Commander, Commander, and Officer— differ from the Legionnaire mainly in size.

After preliminary sketches of a medal have been drawn up, an exhaustive research is made to insure that the contemplated designs do not duplicate any medal of some other country. When finally approved, obverse and reverse designs are reproduced successively in water-color paintings, plaster patterns, and metal plates. Since the latter are several times the size of the final medal, a pantograph is used to reduce the designs to actual size on steel "hubs." From these are made the female dies between which a sterling-silver blank is subjected to repeated striking. All that then remains is for the piece to be color-enameled and gold-plated, if this is called for by the design. After a final finishing, another decoration is ready for presentation.

4 Any surplus stock remaining around the edge of the medal after it comes from the pressing operation is trimmed with a jeweler's saw. Edge is then filed and polished

5 The Legion of Merit's design calls for perforations to separate crossed arrows that appear between the arms of a cross. These tiny holes are made on a drill press

6 After it has been colored by hand with hard-fired enamels in accordance with original specifications, and then gold plated—the medal is ready for presentation

"Smoke" Comes

SPREAD BY THE SQUARE MILE TO CHEAT ENEMY BOMBERS

The Army finds a magical way to hide troops, ships, factories, and even cities in a chemical haze made from a formula by Dr. Irving Langmuir,

By BRIG. GEN. ALDEN H. WAITT
and ALLEN RAYMOND

PRECISION bombing by daylight, such as American Army flyers are doing with deadly effectiveness in Europe, is absolutely impossible for enemy airmen on at least nine days out of ten in several of the most vital defense areas of the United States. No bombsight can pierce the vast artificial fog which our Army's new M-1 smoke generator throws out as a screening blanket over military objectives.

An armor of artificial haze or fog has so proved its effectiveness in North Africa that one German bomber pilot was heard complaining by radio in mid-air to another that he couldn't find his target "because of that damned smoke." On the field of combat large-area smoke screening has made dive bombing or torpedo bombing absolutely impossible where used over concentrations of men or ships.

The use of smoke to blind an enemy in warfare is an old story. But the Army's M-1 mechanical smoke generator is something so new that several key principles basic to its successful performance still are military secrets. It may be told, however, that with a few of our latest generators a few hundred men or women operatives can absolutely blot out areas as large as any of America's strategic canals, navy yards, airplane factories, or other military supply centers from the view of enemy airmen, on almost any day or night in which flying is possible.

What nobody can see, nobody can bomb with precision. The R.A.F. found that out when trying to destroy the cruisers *Scharnhorst* and *Gneisenau* in the harbor at Brest. For many a day British airmen dropped their missiles hopefully toward these valuable targets. Those cruisers escaped. One reason they got away was the Germans' use of a protective smoke screen all around them —a screen now antiquated as compared with America's latest invention for the purpose.

Before Pearl Harbor, the Army set out to improve American smoke-production methods as swiftly as possible. Smoke generators now growing obsolete were already in use for the screening of limited areas, but what the Army Service Forces wanted was a device for screening many square miles, if necessary.

One of the most widely used methods for production of smoke screens at that time was the partial burning and distillation of low-grade fuel oils in generators similar to the orchard heaters and smudge pots used in California fruit groves.

These oil smoke pots—the best we had—produced a dark-gray smoke which was effective in obscuring small areas, but their use was expensive in men and material. The smoke pots had to be serviced frequently, almost every hour through the nighttime, when they were used. They required many men for operation, and provided little or no protection if used during the daytime. The smoke emitted was irritating to the noses and throats of people in regions protected. It stained their clothes and hampered their work.

The job of developing and providing smoke chemicals and devices is entrusted to the Chemical Warfare Service under the Army Service Forces.

No method of smoke projection existed capable of the large-area daytime screening which this Service sought. The problem of finding one was put up to the National Defense Research Committee, headed by President James B. Conant of Harvard. This is the committee, established in 1940, which has enlisted about 6,000 scientists in 100 schools and 200 industrial laboratories for war research service, and which in January, 1943, was wrestling with about 1,400 research jobs for American armed forces.

One of these scientists is the Nobel Prize winner, Dr. Irving Langmuir, physicist at the General Electric Company's research laboratories, Schenectady, N. Y. Dr. Langmuir was one of the men asked by the National Defense Research Committee to seek the better smoke formula.

At the moment, Dr. Langmuir and an assistant, Vincent Schaefer, were knee-deep in a study dealing *(Continued on page 194)*

Billows of mist pouring from the ten-lipped mouth of the U. S. Army's new M-1 smoke generator cover a whole countryside like clouds or fog. A battery of these with men or women operators could blot out an entire industrial area

I Helped Bomb

HOW DOES IT FEEL TO SPEND EIGHT MINUTES OVER THE HEART OF JAPAN, THEN TO BAIL OUT INTO THE NIGHT DEEP IN CHINA? THIS MAN TELLS YOU

Sergeant Eierman in his flying gear. Hailing from Atlantic City, N. J., he has been in the Army since 1935. For his part in the raid on Japan he received the Distinguished Flying Cross

THE writer of this article flew as an engineer-gunner in the spectacular air raid on Japan on April 18, 1942. Like most of the U. S. flyers, he had to bail out over Chinese territory in total darkness. Relaxation of military secrecy about the raid now makes it possible for him to tell his story.

By JACOB EIERMAN
Staff Sergeant, U.S.A.A.F.

I FLEW on the Japan raid, and it was the biggest show I've ever had a part in. I'd call it a thoroughly successful operation. I know that one bad break forced a change in the plan, and later led to the loss of our planes and a few of our men. But every plane went where it was supposed to go, found its targets, and planted its bombs right where they were supposed to fall.

I have been in the Army since 1935, when I enlisted in the infantry. I transferred to the Air Corps in 1936 and trained at Wheeler Field as an engineer-gunner. Early in 1939 I was sent back to California and assigned to my outfit, the 89th Reconnaissance Squadron. All the men on the Japan raid, by the way, came either from the 89th or the 17th Bombardment Group.

Early in 1941 we got our B-25 bombers, North American Mitchells. In February, 1942, word went around that volunteers were wanted for "P." That was our code word for a special mission somewhere outside the country. There were more volunteers than they could use, so we drew lots, both officers and men. My name was the first drawn in our squadron.

We did our main training at Eglin Field, Florida. There we worked and worked on short take-offs with markings on the runways. We also had gunnery and bombing practice, and did long navigation missions of eight and 10 hours, practicing celestial navigation out over the Gulf.

Of course, the boys had some theories about the nature of our mission. One was that we were going to blast a big submarine base in the Caribbean. But that was settled when we went to the West Coast and got charts that showed pretty clearly that we were somehow going to China by way of Japan.

We removed our lower turrets to install extra gas tanks, and also had tanks in the

Japan

End of the flight: Eierman (with canteen in hand) and other flyers being escorted through a Chinese village. A Chinese is holding the arm of Maj. John Hilger, the pilot, who was injured in the landing

bomb bay and the crawlway leading to the rear of the plane. After a final checkup we went to the West Coast, then flew to a rendezvous where our planes were loaded on the flight deck of the aircraft carrier *Hornet*.

At 8:30 the next morning we sailed out to sea, where we met up with cruisers and destroyers which went along with us.

The weather almost all the way across was dreary, misty, and rainy. Occasionally we'd see the sun, but most of the days were pretty bad; that was excellent for us. For the first part of the trip it was a pleasant life. We ate and lived with the chief petty officers, and the food was swell. On a typical day we could get up when we felt like it and get breakfast until eight o'clock. Then we'd go on deck and check up on our planes, adjust them, and go over equipment. To keep in practice, we flew kites and fired at them with the top-turret guns of our planes.

Every day General Doolittle held a meeting with a lecture of some kind, on gunnery, navigation, first aid, or bombardment. One day a naval officer who had been an attaché in Tokio talked about the terrain of Japan and told us ways to tell a Chinese from a Japanese. There wasn't time to learn any language, but we memorized a Chinese phrase, "Meg Wa Bing," meaning "American Soldier."

Our planes made the whole trip lashed to the top deck. We had them dispersed around so they covered the entire deck. It was understood that if we were attacked we would take off immediately and try to land wherever we could—first at Hawaii and later at Midway. If there wasn't time for that we were to push our planes overboard so that the carrier could get her own fighters in action.

After we got west into the danger zone, we had general quarters every day before dawn and before sunset. After sunset general quarters we'd have supper and in the evening there wasn't much to do except talk or play the old Navy game of acey-deucey.

We had been turning the engines of our planes over every other day to keep them tuned up, and now we refueled the planes completely on the afternoon of April 17. We understood that the plan was for us to take off in the late afternoon either on the 18th or 19th, when we would be about 400 miles from Japan. We were to hit there around dusk or a little after, and General Doolittle was to go over about an hour ahead with incendiaries to light up one main target so that the rest of us could get our bearings on that.

But it just didn't work out that way. On the morning of the 18th we suddenly sighted a small vessel. It could have been a fishing boat or a patrol boat, but we never knew. One of our cruisers fired two salvos at it. The first was just over, and after the second

We drew lots for the mission. My name was the first one drawn in our squadron.

Drawings by Fred Rodewalk

there wasn't any more target to shoot at.

But there was no way to tell whether the boat had got off a radio message, so the decision was made to begin our raid immediately, and the order, "Stand by to launch your ships" came over the carrier's loudspeaker system.

We had no chance to eat breakfast, and most of us took off with empty stomachs. The Navy did rustle some sandwiches for us, though, and we took them along. Each man also was issued a pint bottle of whisky for emergency use.

We reported on deck and went directly to our 16 planes, which were now grouped as closely as possible at the back of the deck. There were 80 of us in the plane crews—five to each ship.

We knew we were going on a tough job. At the plane our pilot, Maj. John A. Hilger, told us we probably just didn't have enough gas.

"The way things are now, we have about enough to get us within 200 miles of the China Coast, and that's all," he explained. "If anyone wants to withdraw, he can do it now. We can replace him from the men who are going to be left aboard. Nothing will ever be said about it, and it won't be held against you. It's your right. It's up to you." Not a man withdrew, although I don't suppose any of them felt any better than I did.

The first ship was ready to take off about 8:20 a.m., and we all stood around, watching and sweating it out. We had done plenty of practicing—on land—but this was going to be the first real take-off from a carrier with one of our big bombers. To make it worse, the sea was kicking up nasty and the carrier was rolling and pitching.

But General Doolittle went first. He just set the brakes, gunned his engines, got his signal from the carrier's control officer, and took off. He used only about 200 of the 300 feet of runway he had, and just seemed to jump the plane off into the air. Everybody felt better after seeing that.

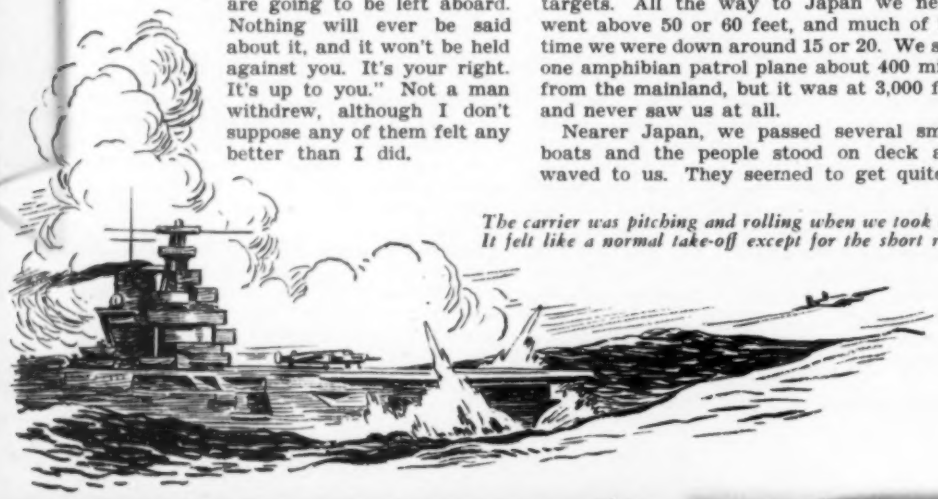
The toughest thing about the take-off, by the way, wasn't the run itself; it was the fact that our bombers had less than six feet clearance between the right wing tip and the "island"—the big bridge structure of the carrier. That was the worst hazard. After four or five ships got off, one plane started without lowering the wing flaps. It ran right off the end of the deck and seemed to drop, but the pilot managed to keep off the water and gained altitude slowly. He was all right.

Finally our turn came, and there were two other ships left to go. It felt like a normal take-off except for the very short run. The rolling and pitching was so bad that it took 15 men to hold the plane steady.

The biggest thing I remember about that take-off was that I saw the carrier take water over her bow just as we were heading down to it. Major Hilger and the copilot, Lieut. Jack A. Sims, were in their regular places and I was crouching directly behind and between them. Lieut. J. H. Macia, the navigator-bombardier, was in his navigator's place, and Sergeant Bain, our radio operator-gunner, was at the radio desk.

We got off, circled the ship once to check our compass, course, and drift, then started off. There was no flight formation. Each ship was on its own, with orders for its own targets. All the way to Japan we never went above 50 or 60 feet, and much of the time we were down around 15 or 20. We saw one amphibian patrol plane about 400 miles from the mainland, but it was at 3,000 feet and never saw us at all.

Nearer Japan, we passed several small boats and the people stood on deck and waved to us. They seemed to get quite a



The carrier was pitching and rolling when we took off. It felt like a normal take-off except for the short run.

As we neared Japan, people on boats waved to us. They thought we were Japanese planes.

kick out of seeing "their" planes patrolling so close to them. We tried out our machine guns and the nose gun jammed and couldn't be cleared. But the pilot ordered me to stay in the nose and be ready to drop the bombs if anything happened to Lieutenant Macia.

We approached land skimming the waves at 20 feet. I guess we had all been hungry and no one realized it. But just as we came in over land, Sergeant Bain started eating a sandwich—I remembered that later.

By then we were all thinking about our bombs. Our ships carried some demolition and some incendiary bombs. We had a special load of four 500-pound incendiary clusters—that is, each cluster contained 128 four-pound incendiary bombs. Before the take-off we had watched a little ceremony on board, when the carrier's captain went up and attached some Japanese medals to the first bomb that was going to be dropped from General Doolittle's plane.

We came in over Japan just above the treetops. It didn't look as cluttered and crowded as we had expected. It was like a rural district anywhere, with green fields and open country. It was a brilliant sunshiny day by now, without a cloud in the sky.

Our target was Nagoya, a big industrial center, like Pittsburgh in the U. S. We hit there about 1 p.m. after circling from the bay so as to come back and make our run from the inland. We knew Tokio must have caught it nearly an hour before, yet no one seemed ready for us. We had no trouble locating our targets, which were zigzagged on either side of a very prominent straight canal leading to the bay. There was no AA fire, and not another plane in the sky.

The first target was a big army barracks near the Nagoya Castle, an ancient landmark. We were now at 1,500 feet and doing 200 miles an hour; that had been arranged in advance so we could use the improvised "20-cent" bombsight. We did not carry the regular Norden bombsight for fear one might fall into the enemy's hands.

We let our first cluster go on the barracks and just then some flak began to come up. They weren't too close—black puffs that looked like 37-millimeter stuff. The funniest reaction was from Sergeant Bain. I heard him on the plane's intercom phone, saying, "Major Hilger, sir, those guys are shooting at us!" He was talking in an indignant Carolina drawl, and he sounded just as though he figured those fellows were breaking the law.

The Japs couldn't seem to get our speed and altitude right. Some of the stuff was so far off it didn't seem that they were really trying. I saw only one mark on the plane—a little hole near the running light on the left wing tip.

Our second target was a big arsenal or some kind of army depot. Now, I hadn't seen the first bomb land, but I sure saw this one; it went right down on the target, dispersed beautifully around it and hit particularly hard around one corner.

The third target was an oil-storage warehouse. I saw that one and it seemed like a perfect hit. The AA fire slowed down then; I suppose we had run out of the area where the guns were. But it started up harder than ever as we approached the fourth and last target, the Mitsubishi aircraft works. That was a beautiful hit, too. I could see the bombs strike and flames burst up all over it. Of course we couldn't stick around long enough to check up on exactly how much damage we had done. I saw a funny thing there, too. As we passed over, a cleaning woman rushed out of one door and shook a mop at us!

Major Hilger suddenly called out: "Look, they've got a ball game on over there. I wonder what the score is." It was a baseball game, sure enough, and a big crowd was in

There was nothing below me but air and fog. I never felt anything so lonesome. I really had the blues.

a wild scramble getting out of there fast.

With our bombs gone we went down to low altitude again and came out over the bay. We had one more target—oil tanks on the waterfront to be blasted with .50 caliber machine-gun incendiary bullets. Sergeant Bain, in the top turret, cut lose at them, then climbed down. I looked at him and burst out laughing. His left fist was clenched tight and his fingers were oozing peanut butter and jelly from that sandwich he had started to eat as we swept in over Japan. The whole raid had taken us about eight minutes, and he had never let go.

Well, with the excitement over for a minute, anyway, we felt a little let down. We did see one plane back of us over the city and it suddenly disappeared in a big cloud of AA fire. We know none of our planes was shot down, so I've always supposed some Jap ship came along and caught it; they have a bomber, I think the Mitsubishi 97, which is said to look something like a B-25.

We turned south to run down the coast before heading for China. And now our main worry was about our gas supply. But when we turned west again over the China Sea, we ran into fog patches and squalls, and the storm we were getting into kicked up a 35-mile-an-hour tail wind to help us along.

That made us feel better, although not exactly good. It was still a hit-or-miss proposition. If the tail wind held, we knew we could probably make the China coast. But what then? We were flying low to save fuel, but running into increasingly bad patches of fog. That forced us up to 500 feet, and kept us flying blind most of the time.

By dark we were completely blind, with no way of estimating drift or sighting on a star. We had to go up to 7,000 feet to clear a mountain range we knew was just back of the coast. And farther inland we knew we'd hit even higher mountains. Finally, with less than an hour's fuel left, the pilot told us we were going to have to bail out. I remember we had a long discussion on whether to take our musette bags or not. I took mine, and also salvaged my pint of whisky.

It's funny what you'll think of at a time like that. I was bitterly regretting having to leave the 15 cartons of cigarettes I had bought aboard the carrier at 60 cents a carton. Bain felt even worse. He preferred cigars, and when he went out he had to leave the first box of 10-cent cigars he had ever been able to buy in his life, and he never got to smoke even one of them.

Sergeant Bain jumped out first, and then I went through the bottom escape hatch. That hatch looked awfully deep and black as I went out and I hesitated a minute, wondering whether to go head first or feet first. I finally went feet first and got a good bump in the head. The next thing I knew I was in the air and my chute was open. I shined my flashlight and there was nothing below me but air and fog. I never felt anything so lonesome; I really had the blues.

Just above the earth my light showed water, and I thought it was the ocean. But it was a rice paddy with a stream running through it. I lit running, on both knees, and got out of that parachute in nothing flat. I pulled myself together and walked about two miles to a tiny settlement, but found that all the doors were barred and no one would answer my knocking. It was raining and I was wet and cold and miserable.

After what seemed like hours I found a man and his wife and persuaded them (by sign language) that they had nothing to fear. They took me to their home, next to a big Chinese temple, and called out the whole family. A very old man took charge then, but we still couldn't understand a word of each other's language. They gave me a place to sleep and offered me food, but I played safe and stuck to my own canteen and emergency rations.

The next day a young boy—not over 14—guided me about 10 miles to a larger town where a Chinese officer took me to a military headquarters. I saw a flat map of the world hanging on the wall, and pointed to the U. S. and then to myself. They beamed and understood that, all right. Later Lieutenant Macia showed up, and the Chinese made signs to show us there were three more. Our entire crew was reassembled. Bain was the last to come in. He had been knocked out landing with his parachute and spent the night on a mountain top.

We were all taken then to a big military post where we had our first real meal in China, with fried eggs, sweet sauce, bamboo and bean sprouts, salt bread, and tea. We thought it was a banquet, but it was nothing compared to the luncheon General Ku later gave us at Third War Area Headquarters. They had 50 dishes, including a special treat for us—the American dish, chop suey!

Later we were sent by train and bus to a big air base built for the U. S. Army. From there, one of our C-47 transport ships flew us to Chungking. There we were told that we had been awarded the Distinguished Flying Cross. And at another luncheon Mme. Chiang Kai-shek presented us with the Chinese Army and Navy Air Force Medal.

From China I was transferred to India and from there later ordered back to the United States. And the first thing I did when I landed back in the good old U. S. A. was to go out and mow down a couple of American T-bone steaks.

WHAT YOU SHOULD KNOW ABOUT OUR FIGHTING PLANES

Drawing by Reynold Brown for North American Aviation's "Skyline"

Low-flying Mustangs co-operate with an invasion fleet and clear the way for landing barges carrying men and mechanized equipment

A Fighter from the Ground Up

You'll be hearing a lot about the Mustang in the months to come. This is the story of the plane that brought something new to the war in the air.

By ANDREW R. BOONE

WHEN the history of this war is written, there may be a hundred days underlined in red pencil—a period in which a young aerodynamic engineer and a veteran designer took a theory on airflow and turned it into the deadliest change-of-pace fighter airplane this stage of the war has yet produced. They call it the North American Mustang—the P-51.

To the unpracticed eye, this latter-day miracle may look like a half dozen other fighters powered by liquid-cooled engines. A careless spotter might turn it in for a Messerschmitt 109-G. Its lean, rangy lines are not unlike the Spitfire's. Indeed, they are so conventional that little or no fuss was made over the plane until it saw action against the enemy.

The P-51 was probably the first airplane designed from information gleaned from actual war conditions. Scarcely six months after England had gone to war with Germany, the British Purchasing Commission contacted North American Aviation on the

mass production of an existing single-seater. Although the current product was deemed adequate to match the existing German ships, President J. H. "Dutch" Kindleberger of North American and his staff knew that the production victory was in mass-producing an airplane that could outfly the best the enemy could produce at the projected time in the future when these craft would reach the battle line.

There had been six months of war, and many things had been learned. Among them was the need for high speed at all levels, free from the effect of shock waves. There was adequate evidence that aircraft diving at speeds exceeding 400 miles per hour encountered periods of excessive vibration resembling impact or shock waves.

There appears to be a velocity at which objects passing through the air no longer are able to "part" the fluid body. In the case of a curved surface designed to produce a definite aerodynamic result, like a wing or tail surface of an airplane, the air seems to "pile up" on the highest point of the wing curve, forming stationary compression or shock waves. The speed at which the airflow alters as it approaches the compression point is called the critical speed. This speed can be raised considerably by careful shaping of the wing section and relation of the wing to the fuselage shape.

With the results of six months of air fighting before them, North American's engineers tackled the problem of building a ship that would be a full year ahead of its time when it first saw action. The major problem was to control the smooth airflow over the wings at high speeds so that the ship could perform well at low altitudes where the dense air offered high resistance to the airplane, but still would have enough performance to fight in the thinned-out upper air if enough engine power were provided to take the ship there.

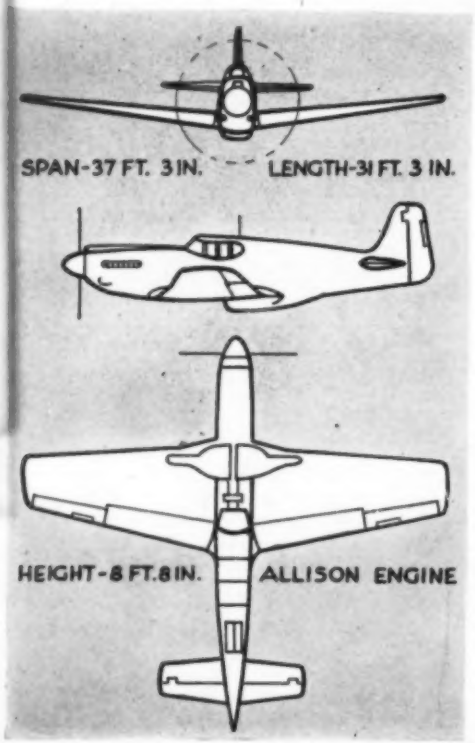
This was practically asking to have one's aerodynamic cake and eat it. Two members of North American's staff came up with a suggestion. Edgar Schmued, former Austrian pilot and now NAA's chief design engineer, and Edward Horkey, a young aerodynamic expert, proposed the use of the laminar-flow wing, a special airfoil section developed in the wind tunnels of the National Advisory Committee for Aeronautics. This wing had never been used on anything more serious than a wind-tunnel model. Admittedly, tests indicated that the airfoil would operate with 50-percent less resistance than an ordinary surface capable of lifting the same amount. Indications were that air would flow smoothly over its surfaces at speeds within a few m.p.h. of that of sound.

There were, however, several important "buts." The wing, to attain the hoped-for efficiency, had to be mated with the slimmest possible fuselage; its surface had to be absolutely rigid. Such a wing was difficult to produce in custom structure. Mass production of such an airplane seemed impossible.

There was no doubt that the Axis had a certain edge in time over the rest of the world. They had been piling up not only matériel but engineering information useful in warfare. In order to head them off, a certain amount of daring was required. By normal engineering evolution, a sample of the laminar-flow wing would have been built and cautiously flown; in due time, an airplane would have been evolved to fly on it. However, the world was in a hurry.

While Schmued and Horkey set about developing production methods for getting out large numbers of laminar-flow wings, the fuselage had to be developed to conform with the requirements of the wing idea. If the air flowed turbulently around the fuselage, the entire effect of the laminar-flow

Straight, rangy lines give the P-51 its superficial resemblance to the Messerschmitt 109-G and the Spitfire. Second-degree curves used in fuselage design replaced the old method of fairing "by eye"



FIGHTING comes natural to this plane with its high speed and maneuverability. At left, the artist depicts the end of a duel with a Focke-Wulf 190, with the Nazi on the way out

DIVE BOMBING. Fitted with bomb racks and brakes, and re-designated "A-36" by the Army, the Mustang has appeared as a dive bomber to pinch-hit for projected types

Drawings by Reynold Brown

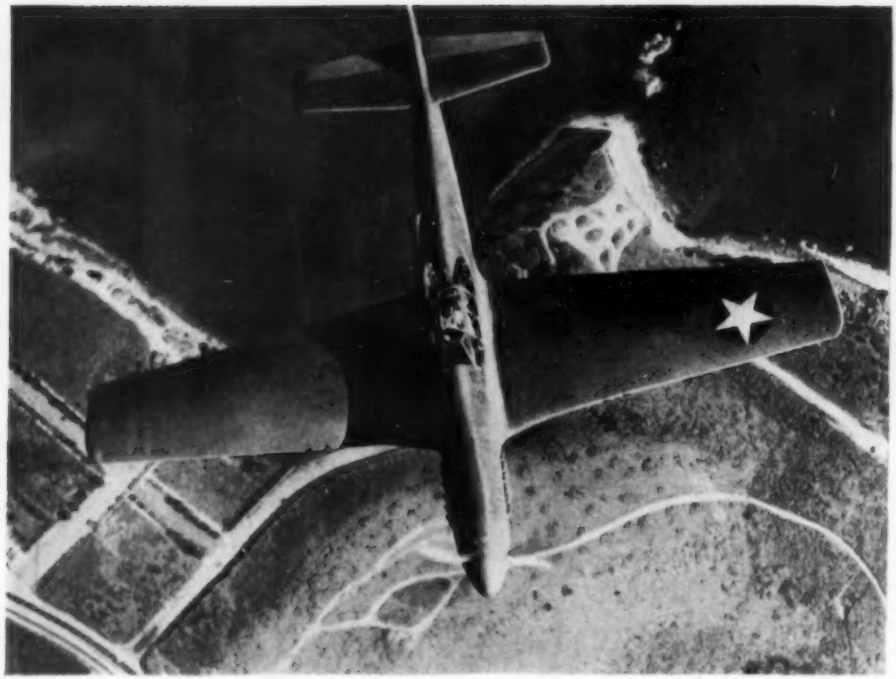
wing might have been destroyed. The engine in the 1,000-plus-hp. class with the lowest frontal area was selected —the liquid-cooled Allison V-1710.

Another "first" incorporated into this ship was the method used in establishing the final lines of the fuselage. Up to this time, an airplane's fuselage was designed by placing whatever had to go inside—the engine, tank, instruments, controls, seat, radio, etc.—in proper order, then locating the distance and position of the tail surfaces and drawing the best-appearing lines possible between the points to create a streamlined body. This method of fairing by eye was, of course, modified by the designer's experience and knowledge of fluid dynamics.

Two young North American engineers, Carter Hartley and Roy Liming, buried this "design-by-eye" method by introducing in the new design a method for developing the form by the use of second-degree curves.

The hundred days' miracle came out with such rapidity that few people took it seriously. Its wing span was 37 feet, its over-all length 31 feet, 3 inches, and its gross weight 7,700 pounds. There was so little to mark it as a spectacular airplane that little or no effort was made to conceal its wonder. Such tricky developments as the superhard rivets used to replace bolts in wing structures were invisible to the casual observer. This weight-saving device was developed by another North American engineer, George Wing. These rivets have a shear strength of 75,000 pounds per square inch. Far too hard to drive,

HEDGE-HOPPING tactics of the P-51 baffle Nazi anti-aircraft gunners. Even if they can get into action in time, they can't depress their gun barrels sufficiently



The "100-days' miracle" in the air. The Mustang enjoys the distinction of being the first American warplane to be designed on the basis of actual war experience. Originally built to replace an existing British single-seater, it incorporated the lessons of six months of war—plus some looking ahead

they must be forced into place by a special tool which presses the rivet's tiny collar into the notched end of a stud, leaving a modified conical head.

Excess length is sheared off automatically. A thousand of these rivets—in reality threadless bolts—replace 798 heavier bolts and some regular rivets in the wing alone, effecting a 60-percent reduction in weight in these materials.

The first ships to see action were low-altitude fighters, operating for the R.A.F. Their job was tagged "Army co-operation." Perpetual critics of U. S. designs accepted that as a signal that the design was a failure and that the best use that the British could find for the ship was as a successor for the slotted and flapped Westland Lysander. Nothing could have been farther from the truth. At the point in the war when the first Mustangs arrived, there was nothing more vital to the conduct of the war than accurate, instant information on what the enemy was doing. The Lysanders and other slow observation and photographic and reconnaissance ships had failed to keep Intelligence posted, as their slow speed had made them targets for anti-aircraft and clay pigeons for fighters.

The maneuverability afforded by the ship gave rise to constant use as a ground-attack ship and fighter-bomber. Stripped of all unnecessary weight and seldom flying at altitudes greater than 1,000 feet, the ships would fly into occupied France and the Low Countries at treetop level. Radio locating devices, which have to be deflected slightly upward to clear ground obstructions, fail to pick up the low-flying craft in time to repel it.

Because the Mustang is one of our "hot" types, too much cannot be said about its present and future. These are just conjectures: That laminar-flow wing gets better as it goes higher. All it needs is the proper power plant to keep it there.

As to the airplane's behavior, little can be said without telling the enemy something he should have to pay heavily to learn. The best hint, however, comes from the pilots. One of them is reported to have wanted to return his extra flight pay. Flying the Mustang was such fun that getting paid for it seemed unnecessary.

Guy Bonham, at extreme left, and a few of his neighbors are shown in the basement "warshop" of his home where, in their spare time, they turn out gasoline strainers for Navy motorboats

The final product, which the group makes under a subcontract for a Flushing, N. Y., boat-building plant. Woodworking machinery was cleverly adapted to the metal job

Basement "Warshop" Fights Hitler

BY POOLING their home-workshop tools, energy, and spare time, neighborhood friends of Guy Bonham, NBC radio entertainer, are waging a private industrial war against the Axis in the basement "warshop" of his New York suburban home. The group, which includes a variety of business and professional men, got its first subcontract job from a Flushing, N. Y., firm engaged in making motor lifeboats for the Navy. The job was to machine and assemble a gasoline strainer. Neither Bonham nor his cronies had ever worked with metal, but by adapting their woodworking machinery to the job, they turned out a trial strainer to the builder's satisfaction—and won a contract for 600 more. The group isn't worried about profits. "We'll be satisfied if we can buy hats occasionally for our 'warshop widows,'" they say.

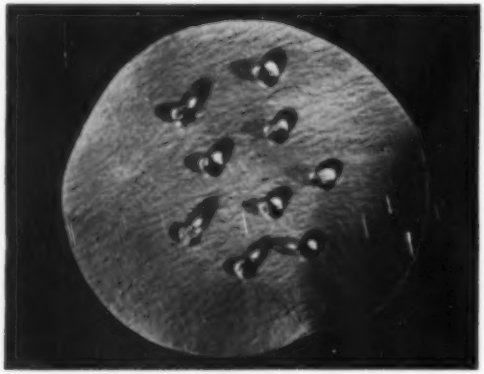
One of the 60 operations required is the cutting of wire gauze. To do the job, neighbor Harlan Howe rigged up the device at left, which has saved many hours in manufacturing time

Nothing stumps these ingenious home "warshoppers." When they found that they did not have the proper tool for leak-testing the finished strainer, they simply built one, using a bicycle pump with a 1914 Pierce Arrow oil gauge to measure the air pressure

PLASTIC FACE SHIELDS that are glass-clear, unbreakable, and noninflammable, have been designed to protect industrial workers from flying particles of wood, glass, and metal. The shield is held on with adjustable head bands and can be swung up from the face with a strap device to avoid smearing the shield with soiled fingers. Held well out from the face, the shield can be worn over glasses or even over a respirator. The device, which weighs but three ounces, is made by the Western Reserve Laboratories of Cleveland, Ohio.

COPPERLESS COPPERS have joined nickelless nickels (P.S.M., Feb. '43, p. 84) in the U. S. Mint's program to conserve strategic materials for military use. By authority of Congress, steel is replacing the 95-percent-copper alloy formerly used in the coins. This will effect a yearly saving of some 4,600 tons of the precious metal.

STEEL COPPER



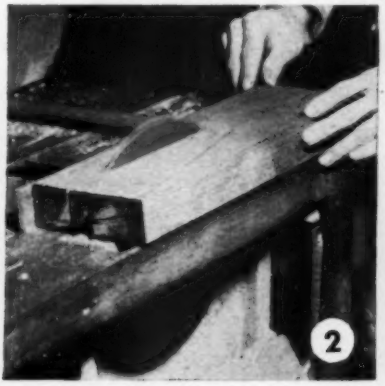
AN INVISIBLE "RAINCOAT," which can be formed on the surface of many materials to make them permanently water-repellent, has been developed by Dr. Winton I. Patnode, General Electric research chemist. The water-repellent film, which is so thin that it cannot be seen under a high-powered microscope, is formed by exposing the material to be coated to the vapor of one of a group of substances known chemically as methyl chlor silanes. An aftertreatment of ammonia vapor neutralizes any corrosive acids. At left, drops of water roll around like marbles on "raincoated" filter paper.

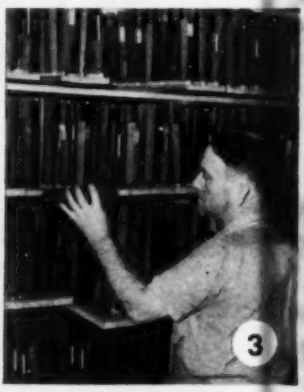
Medieval Woodwind Returns to Favor

The amateur can learn to play the recorder in a few days, while the professional musician masters it almost at once

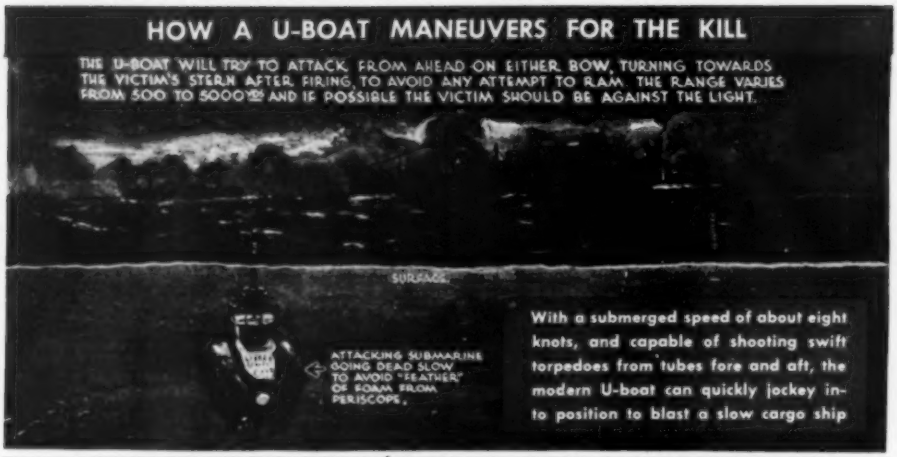
THE recorder, which was popular in Shakespeare's day, appears to be in vogue again. This simple musical instrument, resembling a flageolet, is now being manufactured in this country by William F. Koch at his plant in Haverhill, N. H. Made of South American cocobolo wood, of which Koch has a two-year supply, the instrument has a full chromatic scale with a range of a little over two octaves, and is made in soprano, alto, and tenor sizes. Unlike most other woodwinds, the recorder has no reed, its mouthpiece being provided with a "fipple" like that found on the ordinary whistle.

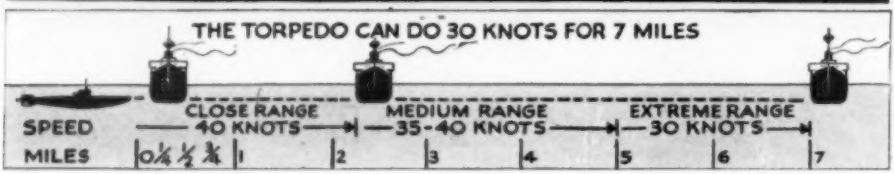
A specially designed tool bores the tapered central hole of the instrument, the outer radius of which is turned on a lathe. Finger holes are bored slightly smaller than their final size, and then brought to precise dimension by hand during the tuning process. The instruments are finished with shellac, which brings out the grain of the wood. Chief outlet for Koch's products is G. Schirmer, Inc., New York.—WILLARD ALLPHIN.





(1) A section cut from a cocobolo plank with a bucksaw is squared (2) at the sides on a circular saw, cut into two or three pieces, depending on the number to be used in the final instrument, and (3) seasoned on drying pegs. (4) A lathe turns the outer radius, and (5) a tuning fork tests the instrument


HOW A U-BOAT MANEUVERS FOR THE KILL
THE U-BOAT WILL TRY TO ATTACK FROM AHEAD ON EITHER BOW, TURNING TOWARDS THE VICTIM'S STERN AFTER FIRING, TO AVOID ANY ATTEMPT TO RAM. THE RANGE VARIES FROM 500 TO 5000 YDS AND IF POSSIBLE THE VICTIM SHOULD BE AGAINST THE LIGHT.
SURFACE
ATTACKING SUBMARINE GOING DEAD SLOW TO AVOID "FEATHER" OF FOAM FROM PERISCOPE.
With a submerged speed of about eight knots, and capable of shooting swift torpedoes from tubes fore and aft, the modern U-boat can quickly jockey into position to blast a slow cargo ship

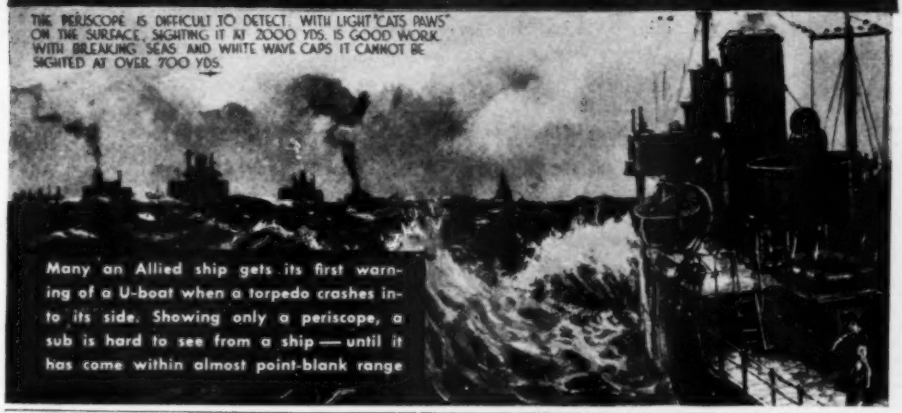


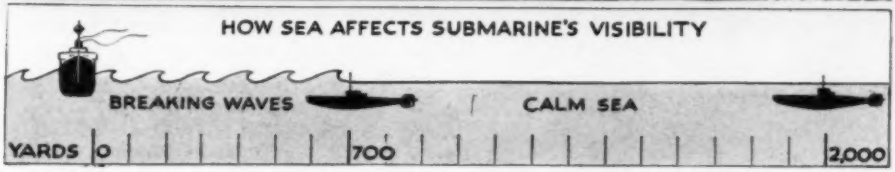
WOLF-PACK TACTICS

FOREMOST threat to the U. S. as a fighting ally on foreign soils, and as an arsenal of democracy that actually delivers the goods, is Germany's great wolf packs of the deep—her fleet of some 700 modern U-boats. With a surface speed of 17½ knots, which is as fast as many ocean liners, and a submerged speed of eight knots—at which tankers and cargo ships often cruise—the modern undersea raider is a very different proposition from that which prowled the oceans in the first World War. The average U-boat now plying the seven seas is about 221 feet long and capable of cruising for six weeks

WHEN THE HUNTED U-BOAT "PLAYS 'POSSUM"
THIS SUBMARINE IS DIVED BY THE USE OF ITS HYDROPLANES (DIVING RUDDERS), THE VESSEL BEING FIRST PUT INTO A DIVE FROM A MODERN U-BOAT CAN "CRASH DIVE" IN UNDER 30 SECONDS.
SURFACE.
AFT HYDROPLANES.
STEAM AND SMOKE FROM HOT EXHAUSTS
IT MAY GO DOWN TO ABOUT 300 FT.
FORWARD HYDROPLANES.
WHEN HUNTED, THE U-BOAT CAN LIE ON THE BOTTOM, IN SUITABLE CONDITIONS, AT DEPTHS OF OVER 250 FT.
WITH MOTORS STOPPED THE SUBMARINE NEVER REMAINS UNDER THE SURFACE AT EXACTLY ONE DEPTH FOR MORE THAN 5 TO 7 MINUTES. HOWEVER, BY VERY ACCURATE TRIMMING (BY MEANS OF ITS BALLAST TANKS) IT IS POSSIBLE TO REMAIN AT MORE OR LESS THE SAME DEPTH FOR LONGER PERIODS.
SURFACE.
SLOWLY RISING OR SINKING.
SUBMARINE WITH MOTORS STOPPED.
WITH ATTACK PERISCOPE FULLY RAISED, THE U-BOAT IS ABOUT 30 FT. UNDER THE SURFACE.
SURFACE.

WHITECAPS HELP TO HIDE ITS PERISCOPE

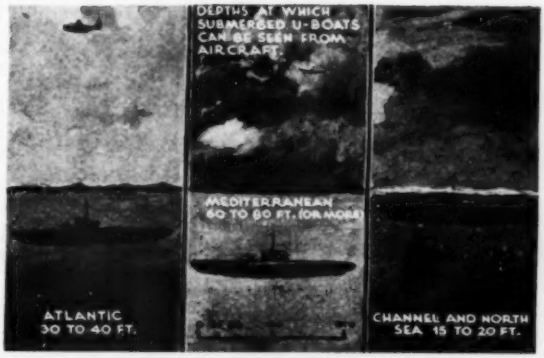

THE PERISCOPE IS DIFFICULT TO DETECT. WITH LIGHT "CATS PAWS" ON THE SURFACE, SIGHTING IT AT 2000 YDS. IS GOOD WORK. WITH BREAKING SEAS AND WHITE WAVE CAPS IT CANNOT BE SIGHTED AT OVER 700 YDS.
Many an Allied ship gets its first warning of a U-boat when a torpedo crashes into its side. Showing only a periscope, a sub is hard to see from a ship — until it has come within almost point-blank range



HERE'S HOW THE U-BOAT HUNTS ITS PREY

or more without refueling. Above deck, in its superstructure, and below deck it can carry a total of from 12 to 14 torpedoes. These can be launched at enemy ships from four tubes in the bow and one in the stern.

Drawings on these pages, made by G. H. Davis for the *Illustrated London News*, show some of the tricks employed by undersea raiders in concealing themselves while they stalk their prey. The Battle of the Atlantic is largely a matter of matching wits with these undersea wolves.


DEPTHS AT WHICH SUBMERGED U-BOATS CAN BE SEEN FROM AIRCRAFT.
MEDITERRANEAN 60 TO 80 FT. (OR MORE)
ATLANTIC 30 TO 40 FT.
CHANNEL AND NORTH SEA 15 TO 20 FT.

Difficult to detect from a ship's deck, subs are easily spotted by planes. Above are various depths at which the subs must travel to avoid being seen

To counteract the danger of plates being loosened by the concussion from depth charges, Germany is welding, instead of riveting, its newest subs

Fighters Styled by

Style and Comfort for the Army Nurse

For arctic wear, this parka-style coat has a lining of thick alpaca pile. Hood is pulled tight by a drawstring

The outer shell is sturdy wind-resistant, water-repellent poplin. These coats are just the thing for service in Iceland, Alaska

Dress uniform of cap, wool jacket, and skirt comes now in the popular olive drab instead of navy blue. Shirt and tie are in khaki

HERE is a fashion preview of clothing and equipment that millions of Americans will be wearing and using in the months to come. With a large fraction of the population shedding civilian dress for uniform, the U. S. Army Quartermaster Corps finds itself the foremost arbiter of style in the country.

Functional design is the keynote of all the garments that bear the "GI" label. While appearance is not neglected (witness the nurse's dress uniform shown above), the main considerations are comfort, serviceability, and protection. Since U. S. troops are serving in all climates from the icy mountains of Alaska to the steaming jungles of the South Seas and the sun-baked sands of North Africa, QMC designers have to

For Formal Occasions

Officers' summer dress uniforms of tropical worsted are now featured in a sand shade of khaki. Cap has matching cover which can be removed for wear with khaki shirt and trousers

Need Clothes Like These
Uncle Sam and Carrying the QMC Label

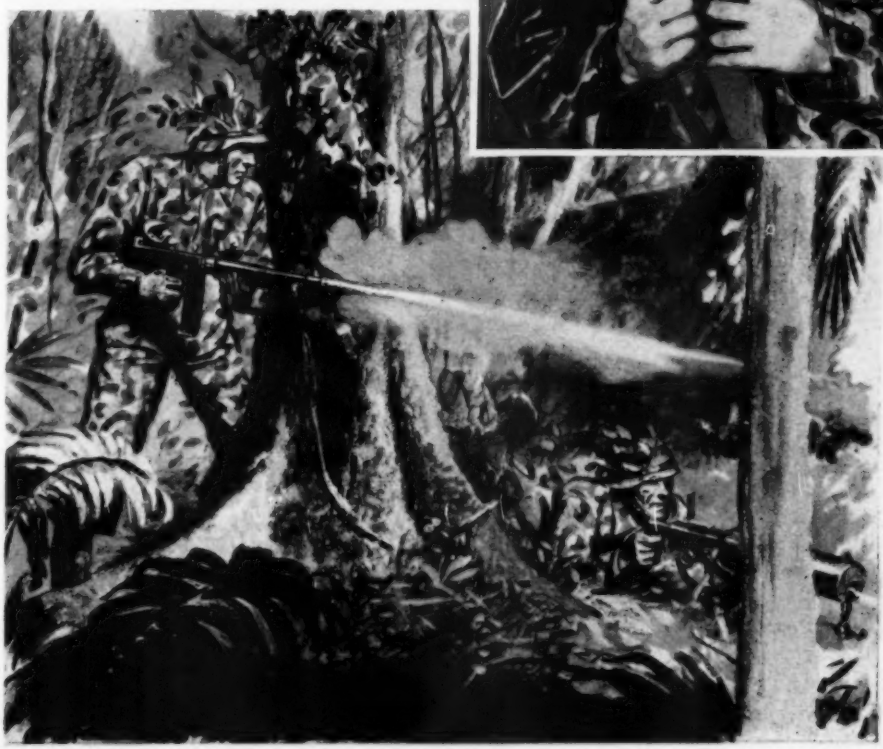
meet a wide range of conditions. Every item they turn out is thoroughly tested by modern laboratory techniques and corrected by the actual experience of forces in the field.

Clothing is only a part of the Quartermasters' responsibility. All the paraphernalia of military housekeeping, from barracks to bivouac, they must supply. As a result, a complete inventory of their "line" would put the biggest mail-order catalog to shame by its size and variety.

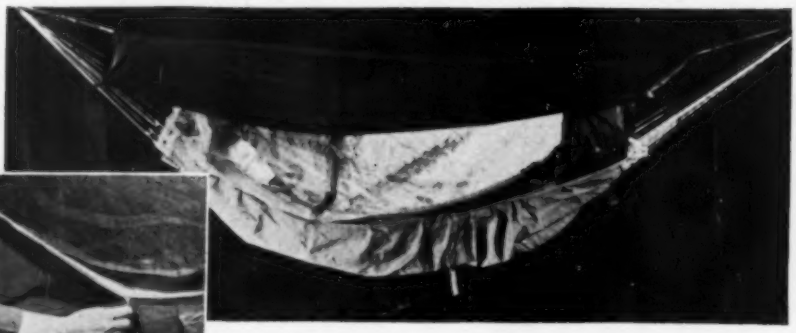
On these and the two following pages are shown a few of the newest items in this mammoth stock. Whether it's a jungle suit or a sleeping bag, the Quartermaster Corps feels that nothing but the best is good enough for its customers.

Jungle Hunting Suit

Inconspicuous one-piece coverall mottled with spots of color. Generous pockets for grenades. Marquisette head net (right) rebuffs insects; inflatable bladders aid in crossing streams



Olive drab is the new shade for underwear. Can be hung out to dry without drawing Zeros. Towels and handkerchiefs to match



Simple as it looks, the jungle hammock boasts a rain-shedding top canopy, a slide-fastened sleeping compartment of netting, and a bottom canopy to protect the rear

Going South?

Campers-out in the jungle will appreciate the comfort and protection of an improved insect bar which can be either slung over a pup tent or rigged alone as seen below. While the netting is fine enough to keep out all pests, it admits plenty of air for comfort. Weighing only 2¾ pounds, it fits easily in the pack

For use with cots in barracks and hospitals, this mosquito bar is rigged to T-bars inserted at the head and foot

With the aid of a plain rubber band, the severe lines of the pot helmet can be relieved with a selection of local flora, as shown at the right

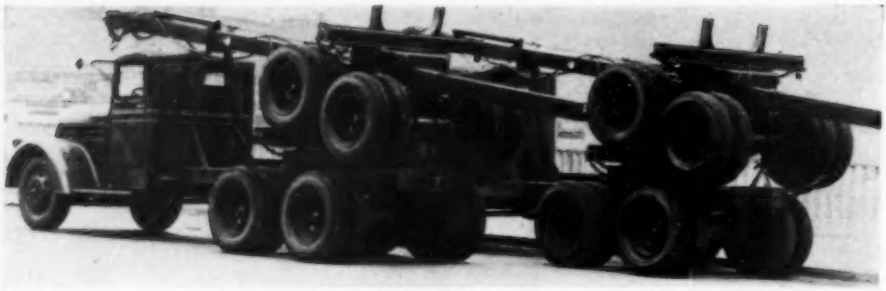
SMART ACCESSORIES, TOO .

Underwear in this year's shade of olive drab . . . headwear you can trim to harmonize with any setting . . . and an inflatable belt for shipboard wear.

For shipboard wear, this life belt is a comfort. A squeeze of a valve fills it with carbon dioxide

. . . or North?

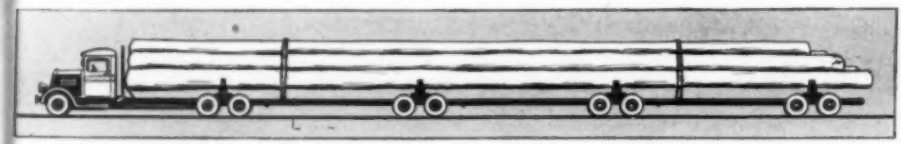
ARCTIC SLEEPING BAG. Really two bags in one. The inner, or "mountain," bag can be used alone as well as with the outer shell. Hood exposes only part of face

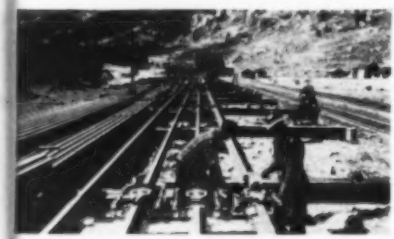


When handling logs of average size, the trailer, after dropping its load, can be doubled up for the return trip. This not only makes steering easier, but also saves wear on the trailer's tires

West Coast Lumbermen's Association

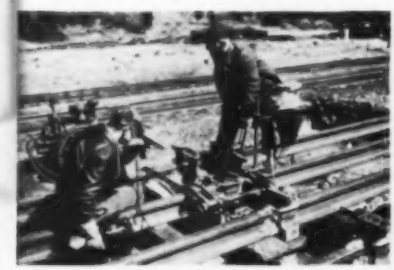
GIANT TRUCK-TRAILERS are being used to haul Douglas firs, standing 160 to 175 feet high in the forests of the Pacific Northwest, to a saw mill at Mount Rainier—said to be the only one with a carriage long enough to handle the logs while they are being cut into 132-foot keels for Navy wooden mine sweepers. The truck itself has 12 forward and four reverse speeds. The trailer, when made up of three units as shown below, rolls on 24 wheels and can carry a load of 120,000 pounds. Hauling the "big sticks" to the East Coast on three flat cars presents another problem in transportation. Routing must be carefully planned so as to avoid sharp curves and low tunnels as far as possible, and thus insure that the precious cargo arrives without damage.





Before being welded, joints were clamped in position, and rail ends preheated and checked (below) with an optical pyrometer

WELDED 1,000-FOOT RAIL SECTIONS recently enabled the Denver and Rio Grande Western Railroad to lay 17,000 feet of track in the Moffat Tunnel near Denver without halting heavy war traffic. In each section 23 pieces of 130-pound rail were joined with welding material from crucibles specially designed by the Metal and Thermit Co., of New York. The welds were radiographed with $10,000 worth of radium, used in place of an industrial X-ray machine, which would have been impracticable. A locomotive then pulled the sections into the tunnel on ties riding on the existing rails.



At right, welding material drops from crucible to fill crack between the rail ends

ZOO DISPLAYS ITS COLORED JEWELS

RARE tropical species of the brilliant-colored hummingbird are now on dazzling display in the "Jewel Room" of New York's Bronx Zoo. Captured in Costa Rica, the group includes 10 species which are exhibited alive here for the first time, as well as specimens of the world's second smallest bird—the Scintillant Flame-bearer, measuring 2.7 inches in length. The birds were caught with chewing gum stuck on the end of a pole.

Photographs by Arthur Sasse

The remarkable "shots on the wing" above and at left were taken with an ultrahigh-speed camera. At the instant these pictures were snapped, the wings of the birds were moving at a speed of 60 flutters a second. Fed from bottles provided with small spouts, the birds are given a select diet which includes milk, honey, and vitamin extract. When dinner is served, which is every five minutes, the birds waste no time getting to the spouts

The zoo also provides a shower once a day in the form of a spray from an atomizer. To make the feedings easier for the birds, the spouts of food bottles are painted with red (below), as this draws their attention. The "jewels" are strikingly displayed under bright lights

Americans smoke more today

What Is the Truth

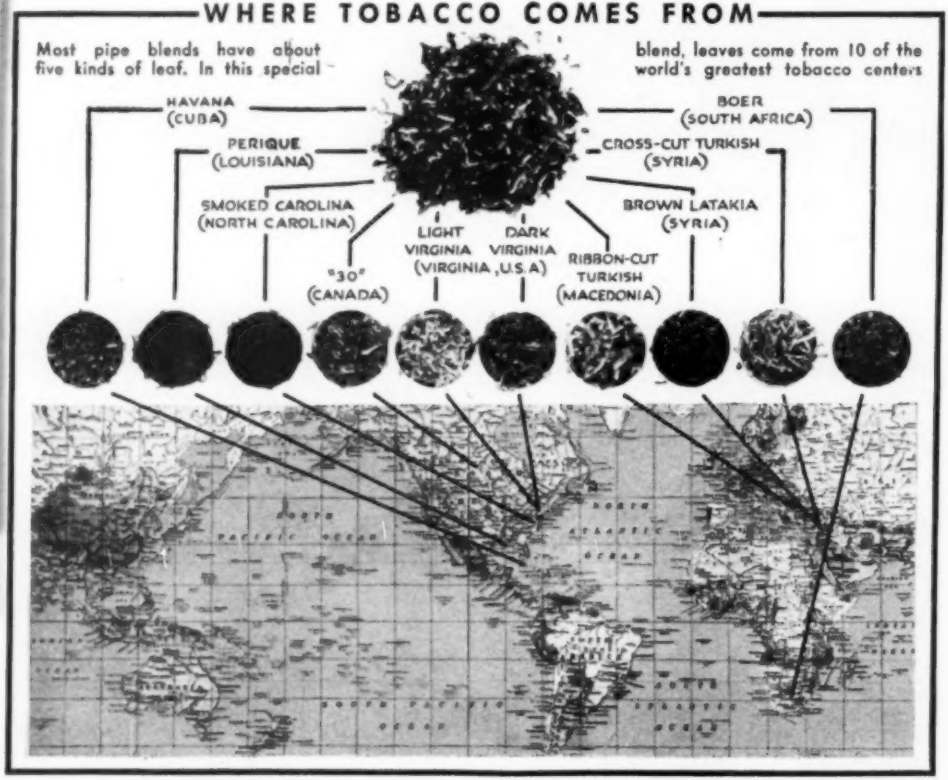
MILLIONS ENJOY IT TO THE TUNE OF $2,000,000,000 A YEAR. YET FEW OF THEM KNOW ANYTHING ABOUT IT. HERE ARE SOME FACTS THAT YOU SHOULD KNOW.

By WILLIAM VOGEL, Jr.

AMERICANS are smoking more in wartime than they have ever smoked before, and the huge American tobacco industry, as a consequence, is booming as it has never boomed in its long history.

The demand for cigarettes last year broke all previous records. According to tax-paid withdrawals of tobacco from Government-bonded factories, cigarette sales totaled 235,839,000,000, a rise of 14.3 percent over the 1941 figure. The final accounting on cigars is not in yet, but the Department of Agriculture, which watches over the progress of smoking like an anxious mother, estimates that well over 6,000,000,000 have gone up in a vast cloud of fragrant smoke. In addition, about 350,000,000 pounds of pipe and chewing tobacco and snuff have been consumed by 16,000,000 users. Preliminary estimates for 1943 indicate that smoking will continue to increase, although not so sharply as last year.

Why are people smoking so much? The tobacco industry has a simple answer: wartime prosperity is enabling people to spend more money on luxuries. They point to the fact that tobacco use declined sharply during the depression. There may be other


WHERE TOBACCO COMES FROM
Most pipe blends have about five kinds of leaf. In this special blend, leaves come from 10 of the world's greatest tobacco centers
HAVANA (CUBA)
PERIQUE (LOUISIANA)
SMOKED CAROLINA (NORTH CAROLINA)
"30" (CANADA)
LIGHT VIRGINIA (VIRGINIA, U.S.A.)
DARK VIRGINIA
RIBBON-CUT TURKISH (MACEDONIA)
BROWN LATAKIA (SYRIA)
CROSS-CUT TURKISH (SYRIA)
BOER (SOUTH AFRICA)

than they ever did before

About Tobacco?

SHADE-GROWN TOBACCO

← is grown under tents of cheesecloth, to produce a light, silky leaf suitable for cigar wrappers

SUN-GROWN TOBACCO

↓ results in a leaf that is smaller, thinner, and darker, and with a tendency to be gummy in texture

factors, of course, such as the heightened nervous tension of hard work, which smoking eases.

What with the industry having more than a billion dollars invested in plant and equipment, retail tobacco sales this year may reach the staggering total of $2,000,000,000. And because smoking keeps civilian and military morale high, the Government has declared tobacco an industry essential in wartime.

What, after all, is this marvelous household weed whose history of recreation and pleasure began when Columbus landed in San Salvador?

Botanically, tobacco is any one of several plants of the genus *Nicotiana*, while the chief American species is *N. tabacum*. Jean Nicot, the Frenchman who brought the leaf to Catherine de Medici in 1561 (and never seems to have done anything else worth mentioning), is immortalized in the name of the genus and of the clear colorless liquid with the chemical formula $C_{10}H_{14}N_2$, which is the characteristic alkaloid of tobacco, nicotine.

Chemically, tobacco contains two percent nicotine in the bright leaf and five percent in the darker varieties. The lighter types are the better West Indian leaves; the strongest are the rank French and German crops. The nature and proportion of tobacco's chemical constituents are largely determined by the conditions under which it is grown, as well as by the curing and fermentation of the leaf. Analyses of tobacco show that it also contains:

IT ISN'T TRUE

that:

—any addition to tobacco is an adulterant.
—a long, white ash means a good cigar.
—finger stains are caused by nicotine.
—cigarette "rice paper" is made of rice.

HOW TOBACCO IS GROWN . . .

Tobacco starts its growth in a protected area, and in soil carefully cultivated and fertilized. A heaping teaspoon of seed is sufficient to sow 25 square yards, which will furnish enough seedlings to plant one acre. After 40 days seedlings are transplanted and set out in rows in the field

Malic and citric acids	10 to 14%
Oxalic acid	1 to 2%
Resins, fats and oils	4 to 6%
Pectic acid	about 5%
Cellulose	7 to 8%
Albuminoids	25%
Ash	12 to 30%

Tobacco smoke is difficult to analyze, but generally it contains varying percentages of nicotine (but never as much as the unburned leaf), aldehydes such as furfural and acrolein, methane, hydrogen cyanide, hydrogen sulphide, organic acids, empyreumatic oils, phenols, pyridine, picoline, ammonia, carbon dioxide, carbon monoxide, water, and tarry distillates.

The ash is generally composed of potash, lime, sodium chloride, and magnesia, in quantities ranging from nine to 40 percent. In addition there also are small percentages of soda, sulphuric acid, silica, and calcium phosphate.

The ammonia and acrolein are the chief irritants in tobacco smoke. Curiously enough, smoke from a free-burning cigarette is alkaline, chiefly because of the ammonia, and is more irritating to the eyes than smoke expelled from the mouth or nose, which has an acid reaction.

The great controversy about nicotine will probably rage as long as there are smokers and nonsmokers. Generally, the best scientific opinion is that nicotine is no more harmful to the average person than the caffeine in coffee or tea.

However, the amount of nicotine in tobacco "has no strict relation" to that in the smoke. This is the opinion of Dr. Walter S. Mendenhall, professor of pharmacology in the School of Medicine of Boston University. Tests reveal that the manner of smoking may have much more to do with increasing the nicotine content of the smoke than the tobacco itself. A violently-puffed, rapidly smoked cigarette commonly throws off a lot more nicotine than one consumed at a leisurely rate. The same is true of the irritating aldehydes, which may be greater in a fast-smoked, hot cigarette than in a cooler one. Much of the tar and other waste products in smoke are filtered out in the cool, unburned portions of a cigarette or a cigar.

Tobacco is a wonderfully adaptable plant and can be grown almost anywhere in the world. There's a catch in this, however; while adaptable, tobacco is extremely sensitive to conditions of soil and climate. For example, two such different types of seed as Zimmer Spanish and Connecticut broadleaf, when grown side by side, produce leaves which can scarcely be told apart. Yet when the former is grown in the Miami River Valley of Ohio and the latter in Connecticut, the Zimmer Spanish crop makes good filler for domestic cigars, while the broadleaf makes silky cigar wrapper. This peculiarity also works in reverse: North Carolina has four principal tobacco-growing regions, or "belts." Plants from one belt simply will not grow at all in another, even though only a creek or a hill separates them.

With minor differences, growing tobacco is the same in Sumatra, Virginia, Asia Minor, or wherever commercial tobacco is raised. In Cuba, for example, the rich loam of Pinar del Rio Province, which produces 70 percent of the Havana crop, rests after the winter harvest till June. After fertilization and the summer rains, the fields are plowed and more fertilizer is applied. In the fall there is intensive cultivation by plow, harrow, and drag to prepare the fields to receive the brownish seed, so fine that a teaspoonful will produce an acre of plants.

Safeguarded from weeds and insects, the seedlings grow for 40 days. In December, transplating begin; all plants that show signs of dying are replaced after a few days with strong ones. If the tobacco is to be shade-grown for wrapper, men on stilts spread huge bolts of cheesecloth on frames eight feet high to protect the leaves from the sun.

When the plant is several feet high, buds

Above, the small seedlings are being transplanted to a sun-growing area with a machine which both covers the plants and waters them

In this shade-growing area a covering of cheesecloth is stretched overhead to reduce the amount of sunlight on the wrapper leaf

...AND HOW IT IS CURED

Cigar tobacco is usually cured by fermentation. In cigarette tobacco, however, both fire curing and sun-and-air curing are employed. The tobacco shown below is shade-grown wrapper, which, threaded in pairs, is being hung up for drying

Panels that swing out from the sides of the drying barn permit a careful control of ventilation. Flue curing, in which wood smoke is brought into a curing barn through a series of flues, is commonly used on yellow and mahogany tobaccos

HOW CIGARS ARE MADE

1 The cigar maker first gathers up enough filler material to form the cigar, then molds it in his hands to a well-shaped body

2 He then rolls a binder leaf around the body to form a "bunch." How a cigar is built often determines how it tastes

3 The bunch is trimmed to size by clipping the overlong filler leaves. Fillers may also be "scrap," or smaller, broken leaves

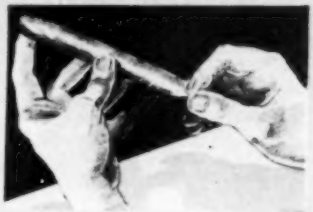
4 Laying the bunch aside for a moment, the cigar maker carefully selects a shade-grown wrapper leaf and expertly trims it off with his knife

5 The cigar maker's best skill comes into play as he rolls the spiral of wrapper leaf around the bunch

6 With a drop or two of colorless, harmless adhesive, he seals the "flag" in place around the head of the cigar

7 Rolling the cigar back and forth under a flat, smooth board gives it its uniformly cylindrical shape

8 The last job is to trim the "tuck." After a final examination, the cigar goes on to other expert hands for color selection and packing



Drawings from Cigar Institute of America

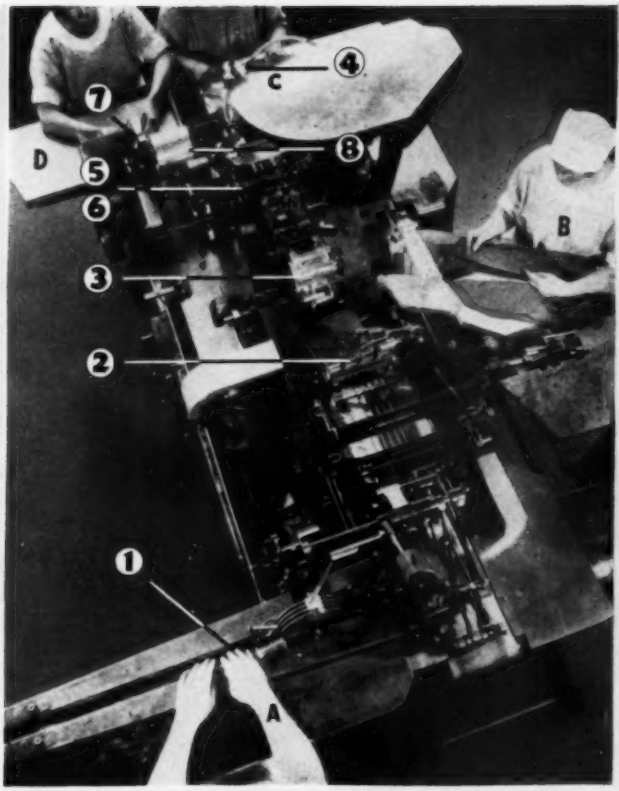
HOW TO SMOKE A CIGARETTE

When you first light up, hold the match at a slight distance so as not to contaminate the tobacco with sulphur. Puff slowly. A hot cigarette increases the vegetable tars in the smoke, destroys the flavor, and increases the nicotine content. When "idling" a cigarette, hold the lit end upward. This prevents the unburned tobacco from getting hot, and avoids finger stain.

begin to appear, which if allowed to flower would draw strength from the leaves. In a process called "topping," they are nipped off by hand. At the same time, sick-looking leaves are removed, as well as large numbers of new shoots, called "suckers." At maturity the plant will have about 12 to 14 leaves.

Although the growing procedure is virtually the same, there are many differences in curing. Cigar tobacco, generally, is cured by fermentation alone, no artificial heat being used. In the cigarette-tobacco regions of Virginia, North Carolina, and Kentucky, heat is used in fire-curing and flue-curing, while sun-and-air curing is similar to the fermentative method commonly employed in Cuba.

Flue-curing bright yellow tobacco in Virginia and North Carolina is probably the



With mechanical fingers which are said to be every bit as delicate as those of the most expert craftsman, this machine turns out the work much faster—a perfect cigar in less than seven seconds. The progressive stages of manufacture have been numbered to correspond with those of the hand method at left

Courtesy of General Cigar Co.

most difficult task of the tobacco planter. Smoke enters the curing barn through flues. Drying the leaves rapidly to obtain the yellow tint requires 90 degrees F. of heat for 36 hours, then two hours at 100 degrees. Every two hours thereafter the temperature is increased 2.5 degrees until the critical point of 110 degrees is reached. Now the yellow color appears, but from there on it rests entirely upon the judgment and skill of the planter how long the heat should be applied. It may take from four to eight hours, and constant care must be taken to keep the leaves from fermenting.

When the tips begin to curl, the temperature must be raised again, at first to 120-125 degrees, then, after four to eight hours, to 170 degrees, in steps of 5 degrees at a time. This "fixes" the color by driving out all the sap, oils, and moisture, and makes the leaf one of the finest ingredients of a cigarette, highly prized here and in Great Britain.

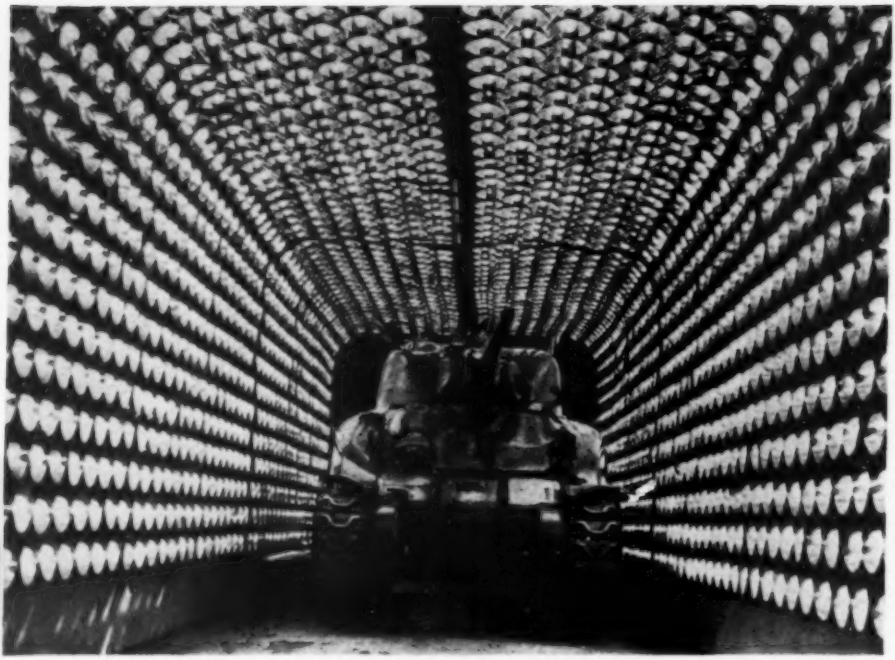
Curing Havana tobacco is done entirely by "bulking" the leaves—that is, heaping them in piles weighing as much as 5,000 pounds. Now a mysterious chemical and bacteriological phenomenon called "sweating" takes place. The moisture in the leaves and the pressure of the upper leaves on the lower ones cause the temperature to rise to 117-120 degrees. This fermentation destroys oils, sap, and juices, and develops "smoking" qualities, as well as a dark-brown color. While it goes on, bulks must be continually rebuilt so that the upper leaves can be placed at the lower parts of the heap.

It is a common belief that any addition to tobacco is of necessity a "dope" or an "adulterant," which impairs the purity of the product. The fact is that pure, harmless flavoring essences are widely used in pipe and chewing tobaccos, snuff, many cigarettes, and some cigars.

"Casing" tobacco is done by swishing it in a flavoring broth just after it has been cured. "Bouqueting" is performed by spraying essences on the tobacco.

Casing and bouqueting formulas are closely guarded trade secrets of the manufacturers. Many exotic essences are used: the Biblical myrrh, honey from the mangrove flowers of Santo Domingo, tonka beans from Venezuela, imported licorice, deer's tongue, St. John's bread (a Mediterranean bean), and essential oils of fig, rose, and geranium.

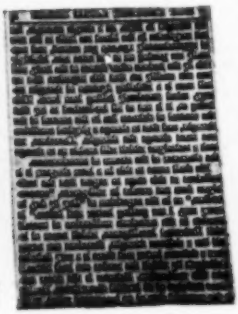
Like wine, tobacco has gathered about it a curious collection of folklore, little of which is true. Many people, for instance, believe that a light-colored cigar is necessarily mild. Actually the strength of a cigar is determined by the curing and blending of its filler. Another misconception is that a white ash is proof of superior tobacco. In reality it means only that a cigar is burning properly. Nicotine is usually held responsible for finger stain from cigarettes. The truth is the discoloration is caused by distilled vegetable tars.



A newly painted tank rolls through the light tunnel at the Chester, Pa., Army Ordnance Depot

A PAINT-DRYING TUNNEL, in which the ceiling and walls are lined with hundreds of infrared lamps, has been ingeniously devised by experts of the Army Ordnance Department at the Chester, Pa., depot to speed up production on the various types of combat vehicles now being used on foreign fronts. Shown above is a newly painted tank, which is being driven slowly through the tunnel of light. Drivers deliberately "loaf" on the job so that the trip will take at least four minutes. However, when the vehicle finally arrives at the other end of the tunnel, its paint has been thoroughly dried by the rays of the lamps. Under ordinary conditions, the drying would have taken 24 hours, and would have required temporary storage space for the vehicles.

After matrix is formed from metal pattern, it is used to make printing plate (right)



PLASTIC PRINTING PLATES are replacing metal ones in a process developed by Bakelite Corp. Weighing only one-eighth as much as their predecessors, they are easily handled, and can be used for half-tone engravings requiring as high as 175-line screens. Under pressure, a thermosetting matrix takes an impression of the type or engraving and then is used to mold the thermoplastic printing plate. Pressure never exceeds 1,200 pounds per square inch, and the temperature, in the second process, is kept at 260 degrees F. The plates, which can be curved for cylinder-press work, withstand long press runs. Lithographing plates of plastic have been developed by Du Pont, saving three to eight times their weight in aluminum and zinc.

WOODEN-SOLED SHOES

Modish "Sabots" Save Leather for War Needs

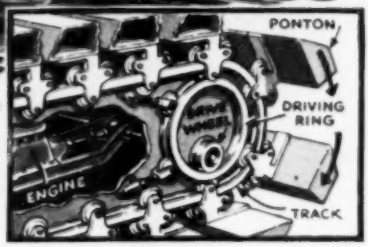
1 OPA shoe rationing has given rise to a wooden-soled shoe which manufacturers are whooping up to beat the ban on the free use of leather. Shown above are the wooden soles being rough-cut to shape

2 Next step is trimming the roughed-out sole down to the proper shape and size for the finished shoe. An outsole laid on the block serves as a pattern for the band-saw operator in the cutting

3 Novel feature of the new "clogs" is a hinged sole for flexibility (below). Leather plugs avoid clatter, and heel insert acts as a shock absorber. The soles are being made by the Sterling Last Corporation

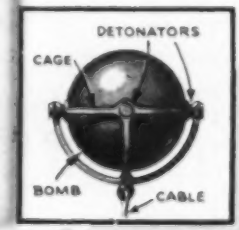
4 Finishing is done at the New York plant of I. Miller & Sons, Inc., where a battery of pressure machines puts uppers on the soles. Called Limbertimbers, the completed shoes (left) are both comfortable and stylish

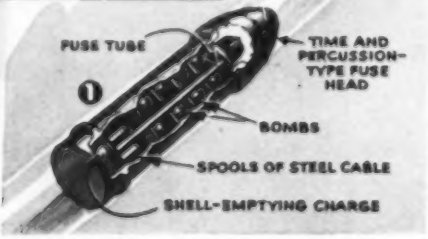
WAR

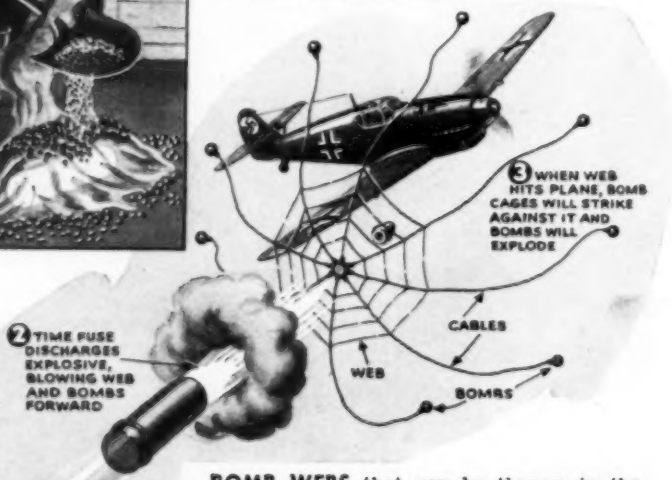


BUOYANT CATERPILLAR TREADS to float and propel seagoing tanks have been suggested by Frank Darragh, Jr., of Beaver Falls, Pa. The sectional view at the right shows how the pontons are driven as an endless track. A rudder of conventional design steers the tank, which is also capable of making beach landings.

INCENDIARY BOMBS can be smothered quickly and effectively by covering them with the common mineral feldspar, according to Joseph Fahey and Michael Fleischer, of Washington, D. C., and William Rubey, of Westmoreland Hills, Md. Melted by the heat of the bomb, the feldspar forms a viscous covering that excludes the air.

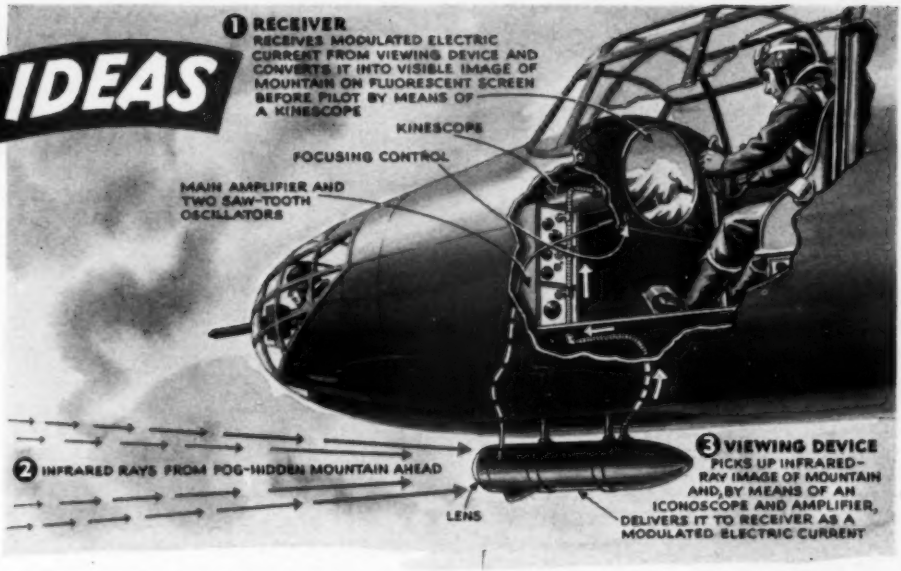




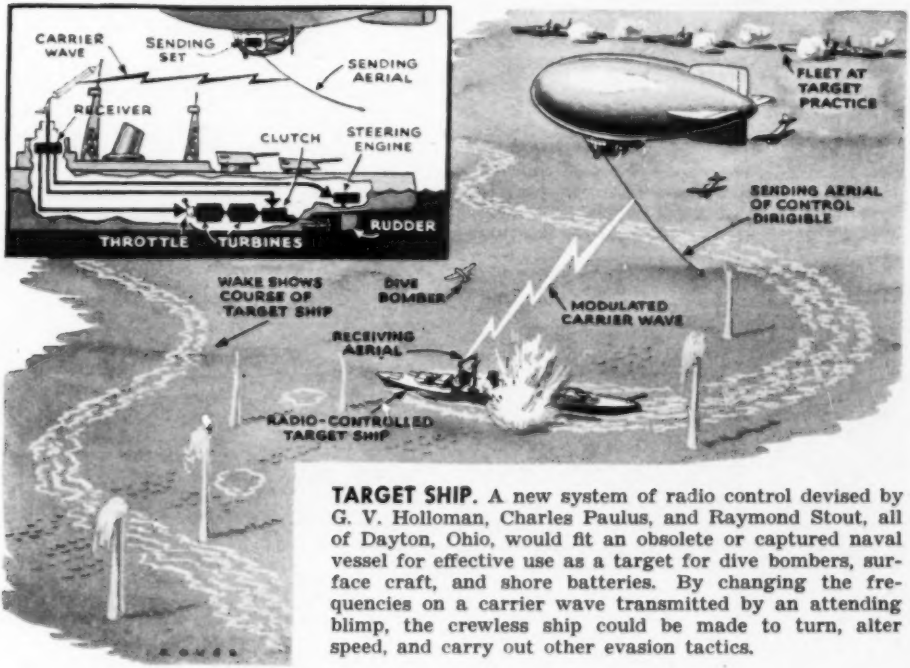

2 TIME FUSE DISCHARGES EXPLOSIVE, BLOWING WEB AND BOMBS FORWARD
3 WHEN WEB HITS PLANE, BOMB CAGES WILL STRIKE AGAINST IT AND BOMBS WILL EXPLODE
CABLES
WEB
BOMBS

BOMB WEBS that can be thrown in the way of enemy planes have been suggested as a new antiaircraft weapon. Encased in a shell, the web is shot into the air and there released by an explosive set off by a time fuse, spreading out like a giant spider web. The instant the plane hits any one of the steel cables, the bombs at the ends of the web's tentacles whip in toward the plane and explode on contact with it, resulting in the plane's destruction. The device was designed by Asa B. Carmichael, of Tujunga, Calif.

IDEAS

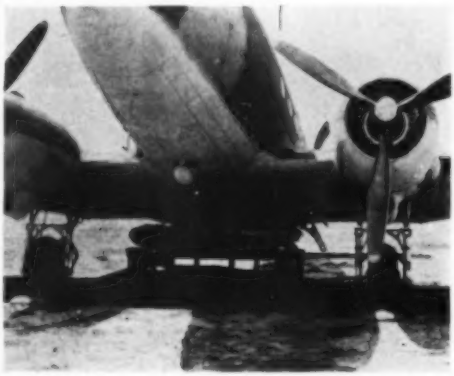

1 RECEIVER
RECEIVES MODULATED ELECTRIC CURRENT FROM VIEWING DEVICE AND CONVERTS IT INTO VISIBLE IMAGE OF MOUNTAIN ON FLUORESCENT SCREEN BEFORE PILOT BY MEANS OF A KINESCOPE
KINESCOPE
FOCUSING CONTROL
MAIN AMPLIFIER AND TWO SAW-TOOTH OSCILLATORS
2 INFRARED RAYS FROM FOG-HIDDEN MOUNTAIN AHEAD
LENS
3 VIEWING DEVICE
PICKS UP INFRARED-RAY IMAGE OF MOUNTAIN AND, BY MEANS OF AN ICONOSCOPE AND AMPLIFIER, DELIVERS IT TO RECEIVER AS A MODULATED ELECTRIC CURRENT

SEEING THROUGH FOG is made possible for pilots by a novel application of television principles. A viewing device slung under the nose of the plane picks up fog-piercing infrared rays which are not visible to the human eye. An iconoscope translates this ghost image into electrical impulses, which are amplified and passed on to a receiving unit where they are converted into a visible image on a fluorescent screen. In addition to removing the hazard of running into a mist-shrouded mountain, the device would assist in landings. Harold A. Adams, of Bakersfield, Calif., is the inventor.



TARGET SHIP. A new system of radio control devised by G. V. Holloman, Charles Paulus, and Raymond Stout, all of Dayton, Ohio, would fit an obsolete or captured naval vessel for effective use as a target for dive bombers, surface craft, and shore batteries. By changing the frequencies on a carrier wave transmitted by an attending blimp, the crewless ship could be made to turn, alter speed, and carry out other evasion tactics.

PREHEATING THE ENGINES of American bombers operating from Alaskan flying fields is done with gasoline-fed "cookers" whose motor-driven fans blow hot air into the vital parts of the engines. Even in sub-zero weather, the motors can be made ready for flying in a matter of minutes. Padded canvas hoods, shown on the B-25 Mitchell bomber above, hold in the heat while the engines get "fightin' hot."



Too big to fit into the Skytrain's fuselage, the wings of a P-40 are strapped underneath the plane

DOUGLAS C-47 SKYTRAINS are being used as "ambulances" to rush fighter planes injured on the African front to distant and secret repair bases maintained on that continent by the Douglas Aircraft Co. The method of transport is both simple and expedient. First the engine of the battle-scarred fighter is detached and put aboard. Then the wings are taken off and strapped on underneath the big plane, as shown directly at the left. Lastly, the slim fuselage of the fighter is slid into the roomy one of the Skytrain. At the Douglas bases the planes are quickly repaired and then tested. The instant they are ready for combat, they speed back to the front under their own power to take up the fight where they left off.

A few husky men gently slide the fuselage of the wounded plane into the cavernous belly of the C-47

Lashed down for the trip to the repair base, the "patient" is all but lost in the giant "ambulance"

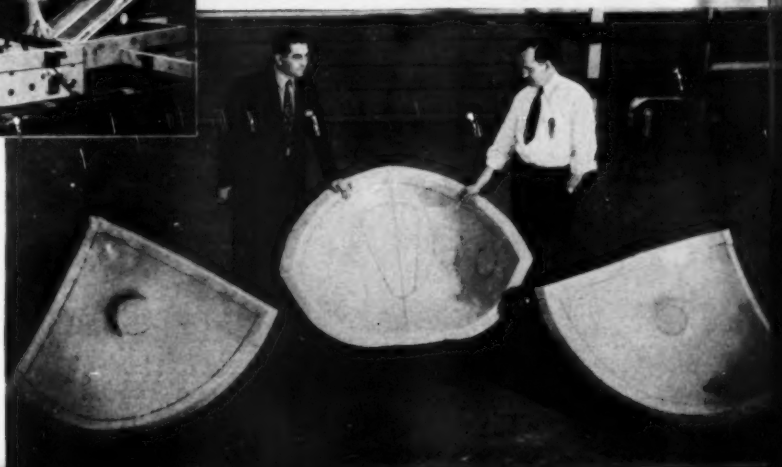
COOKIE OVENS
Bake Plane Jigs from Nutshell Dough

GROUND walnut shells and resin, mixed with an acid catalyst and baked in bakers' cookie ovens, are speeding the construction of warplanes. The "cookies" become drill jigs and forming dies capable of withstanding pressures of four tons. They have helped the Vega Aircraft Corporation save three months of tooling time in building warplanes at Burbank, Calif. M. Basolo, foreman of the Lockheed Aircraft Corporation wood shop, and Carl Hill, plastic expert, perfected the process.

Shells from walnuts like these are ground to flour and mixed with resin and a catalyst in a baker's dough mixer to make plastics for use in airplane drill jigs and forming dies

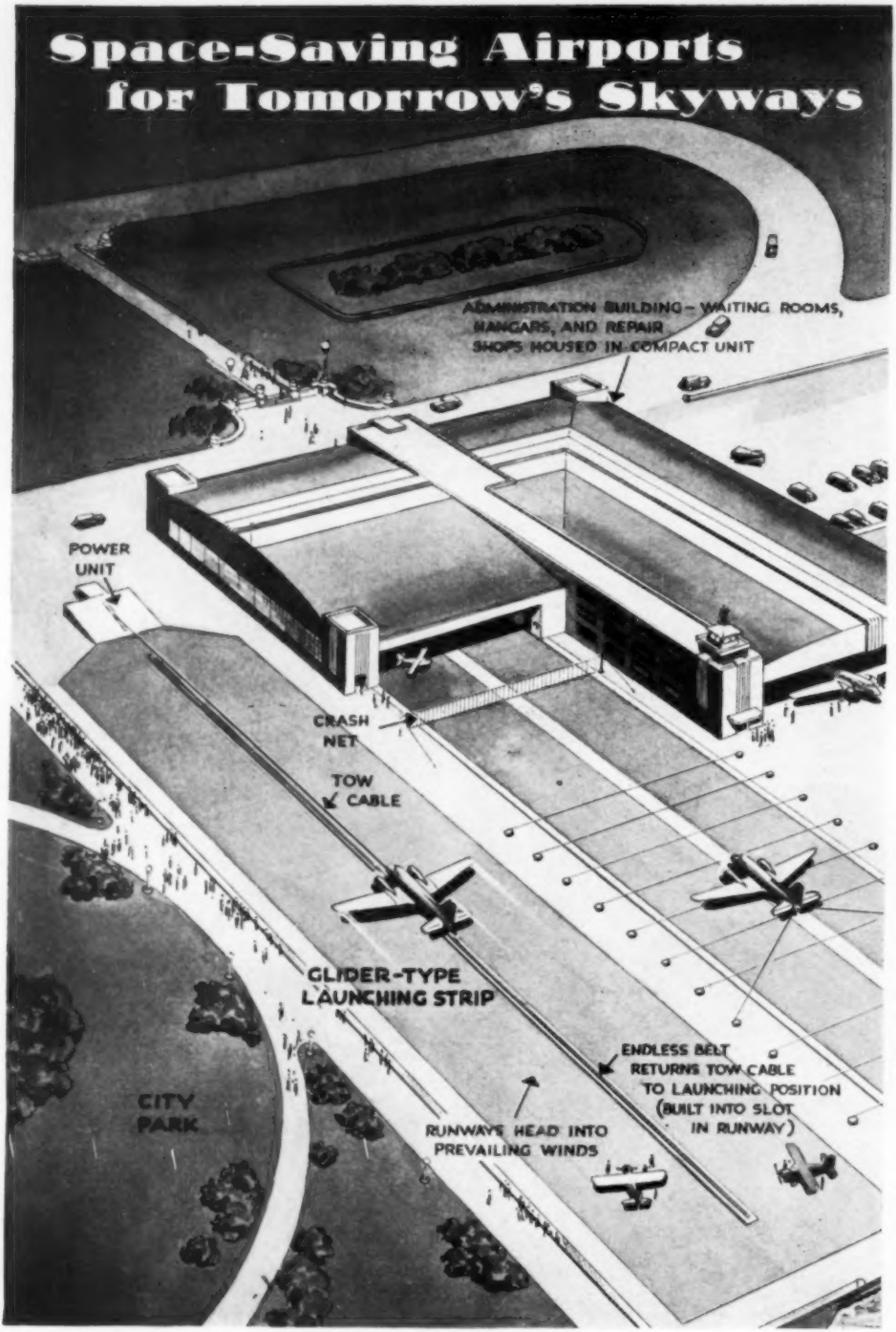
This mixture is poured into molds and baked to hardness in the ovens at right that once turned out cakes and cookies. Two to eight hours at 175 degrees F. are needed in curing

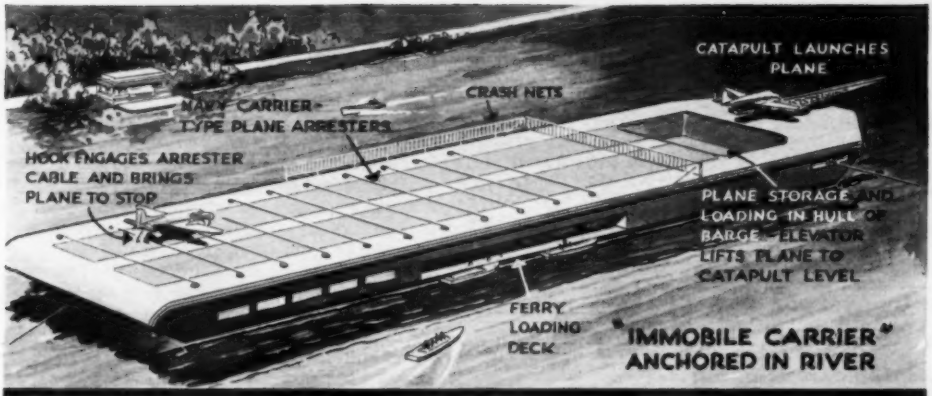
Large forming dies (below) capable of withstanding high pressure are made from nutshell-resin plastic

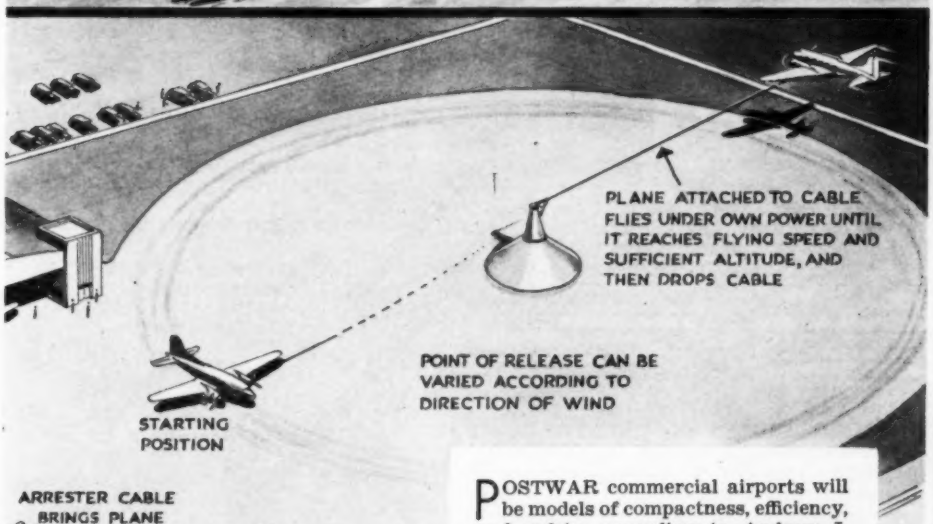


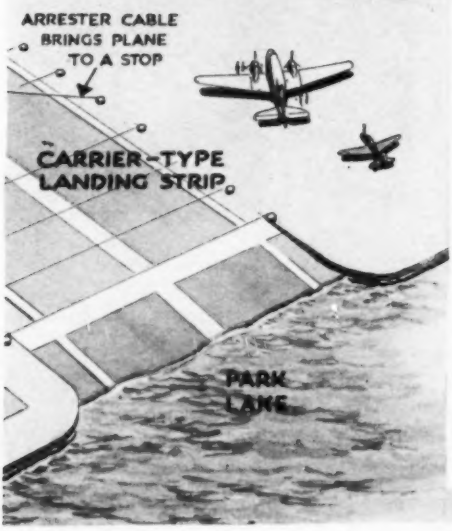
Above are drill jigs baked in cookie ovens to save three months' tooling time in the building of bombers. The plastic resists both oil and chipping

Space-Saving Airports for Tomorrow's Skyways


ADMINISTRATION BUILDING – WAITING ROOMS, HANGARS, AND REPAIR SHOPS HOUSED IN COMPACT UNIT
POWER UNIT
CRASH NET
TOW CABLE
GLIDER-TYPE LAUNCHING STRIP
ENDLESS BELT RETURNS TOW CABLE TO LAUNCHING POSITION (BUILT INTO SLOT IN RUNWAY)
RUNWAYS HEAD INTO PREVAILING WINDS
CITY PARK


CATAPULT LAUNCHES PLANE
CRASH NETS
NAVY CARRIER-TYPE PLANE ARRESTERS
HOOK ENGAGES ARRESTER CABLE AND BRINGS PLANE TO STOP
PLANE STORAGE AND LOADING IN HULL OF BARGE—ELEVATOR LIFTS PLANE TO CATAPULT LEVEL
FERRY LOADING DECK
"IMMOBILE CARRIER" ANCHORED IN RIVER


PLANE ATTACHED TO CABLE FLIES UNDER OWN POWER UNTIL IT REACHES FLYING SPEED AND SUFFICIENT ALTITUDE, AND THEN DROPS CABLE
POINT OF RELEASE CAN BE VARIED ACCORDING TO DIRECTION OF WIND
STARTING POSITION



POSTWAR commercial airports will be models of compactness, efficiency, and safety, according to Andrew J. Fairbanks, professor of aeronautical engineering at Rensselaer Polytechnic Institute, Troy, N. Y., whose conception of tomorrow's airport is here illustrated. Long runways, expensive to build and maintain, will be obviated by catapults, circular take-offs, and flight-arresting gear, as well as by immobile "carriers" anchored in near-by rivers. Private flyers will use helicopters—and "parking lots." Any plane that can stand still in the air, be moved two feet this way, one foot that way, and parked like a car, is the ideal ship, says Professor Fairbanks, for hopping over to the village for supplies or taking the kids to the park for a picnic.

Drawings by B. G. SEIELSTAD

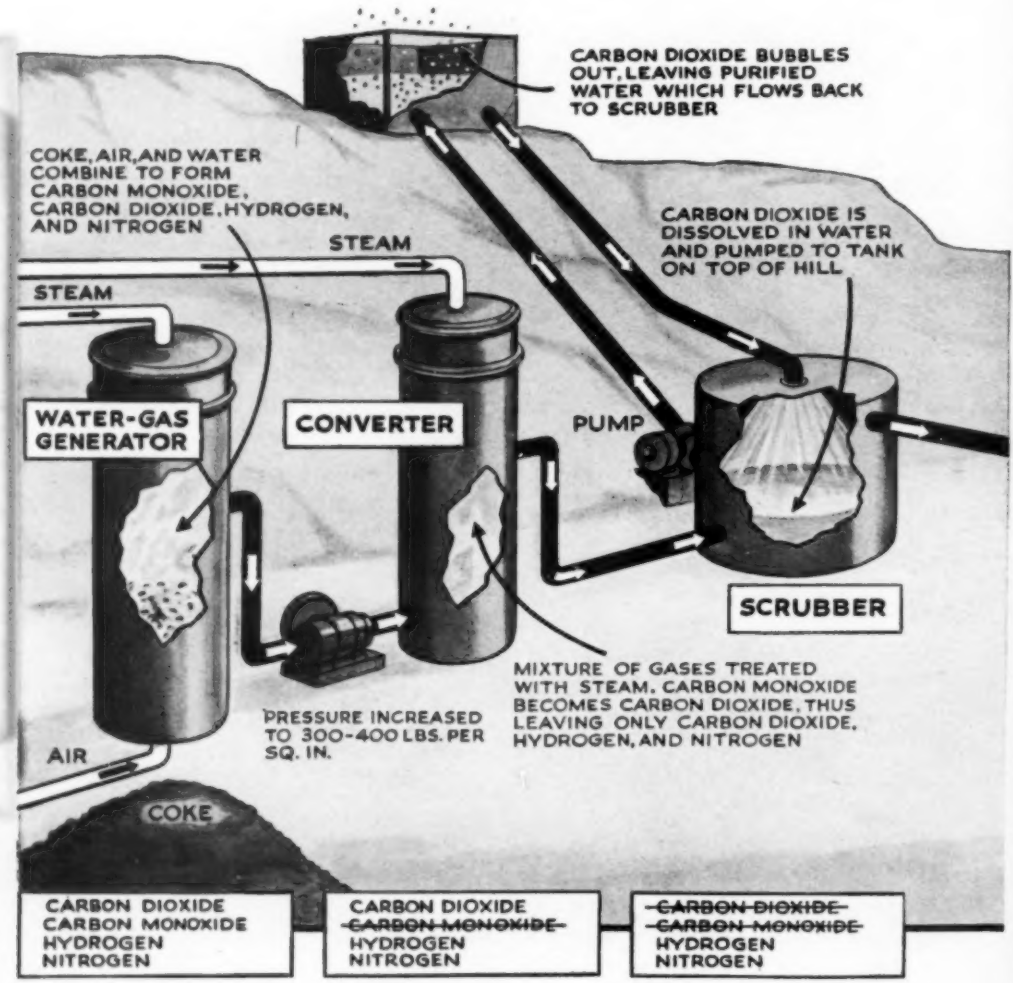
Snatching The

By ALBERT Q. MAISEL

AMMONIA has more than 2,000 peacetime industrial uses. In war, it is indispensable. A basic ingredient in the manufacture of explosives, it also hardens metal parts for planes, tanks, and guns; goes into nylon for parachutes and plastics for plane noses and turrets; freezes food for storage and shipment; makes fertilizers.

EVERY time a 16-inch gun is fired, 120 pounds of nitrogen goes back into the air from which it came. Every bullet, shell, and bomb dropped on Japs or Nazis comes into being only with the aid of ammonia, a simple compound made up of three parts of hydrogen and one of nitrogen. Yet, if we had to fight this war with only the facilities for making ammonia that we had during World War I, we should be licked before we started.

The difference between 1918 and today is that now the United States has

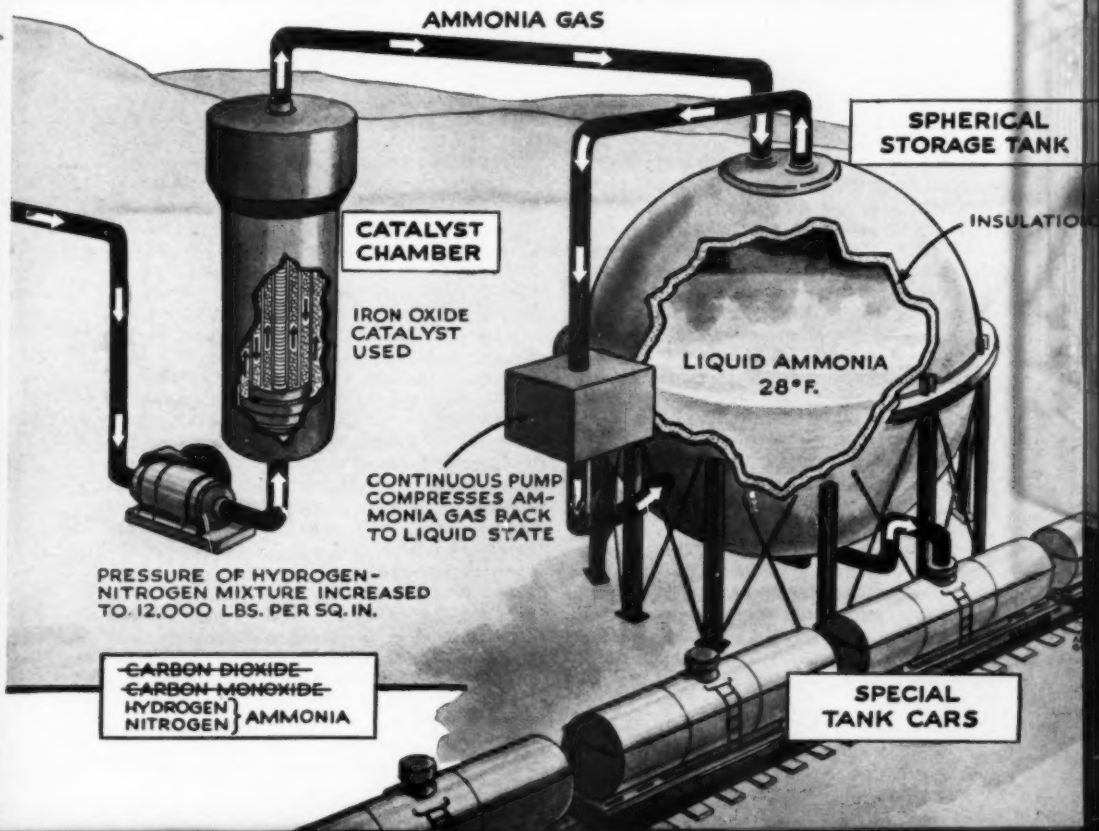


Ingredients of Victory from Air and Water

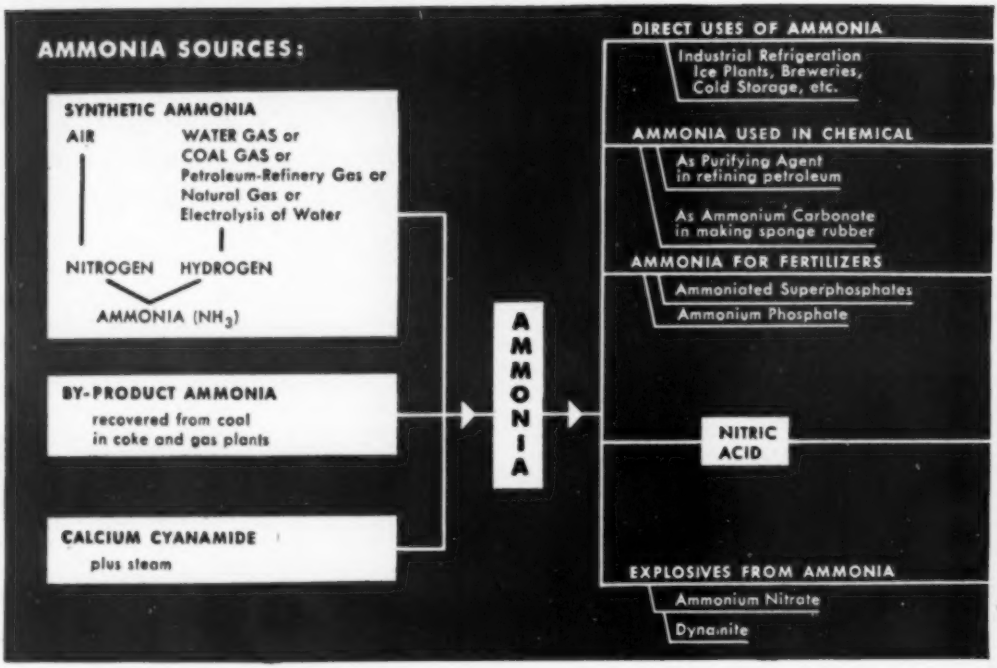
OUR AMMONIA MAKERS PERFORM THE INCREDIBLE FEAT OF TAKING SOMETHING FROM NOTHING TO GIVE US AN UNLIMITED SUPPLY OF EXPLOSIVES AND FERTILIZERS

a highly developed industry capable of producing *synthetic* ammonia—and the hundreds of other war chemicals derived from ammonia—using only air and water as raw materials. In the last war, when all countries relied upon natural nitrates imported from Chile for explosives and other nitrogen chemicals, this country and its allies were lucky. The Germans tried to cut off British supplies from Chile but, after the naval battles of Coronel and the Falkland Islands, they themselves were blockaded without the vital nitrates. In fact, if they had not captured seven ships loaded with Chilean nitrates at Antwerp, they would probably have lost the war by 1916. This lucky capture gave them a breathing spell while they built a plant to use a new process developed by Prof. Fritz Haber—a process which freed them from the need of anything beyond air as a source of nitrogen, water as a source of hydrogen, and coal as a source of power.

During that war, only experimental plants were constructed in this country, for while the process was theoretically not too difficult, the trick was to discover and develop a catalyst that would hasten the union of nitrogen and hydrogen into ammonia. Only after six years of Government-sponsored research did we work out modifications of the Haber process. But when our scientists finally came up with a solution, their process was many times more efficient than the original German development. It made synthetic ammonia so cheap that, within a few years, the annual consumption of ammonia



AMMONIA—WHERE IT COMES FROM . . .



and ammonia derivatives rose manifoldly. Ammonia prices dropped so low that hundreds of new uses became practicable, particularly the important one—in war as in peace—of making fertilizers.

Today, in many commercial plants developed since 1925 and in a number of plants specially built for war work, the ammonia industry is working all-out for munitions production. Some of our 2,000-odd peacetime uses have had to be curtailed to make way for explosives production, but our capacity for this vital chemical is now so large that all really essential needs can still be met.

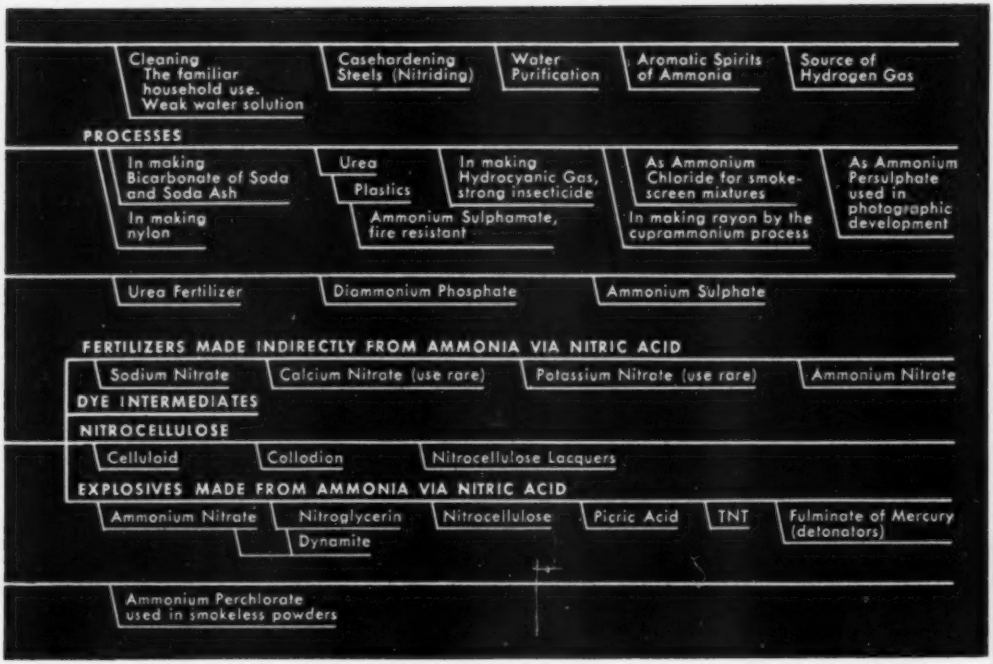
The basic war use for ammonia is that of providing the foundation for explosives. One process converts ammonia into nitric acid, essential in the production of nitrocellulose or guncotton. Nitroglycerin, TNT, picric acid, smokeless powder, and ammonium nitrate are all likewise dependent upon ammonia.

But synthetic ammonia is vital in other ways to our war machine. It is used for *nitriding* or casehardening steels for vital parts of armor plate, airplanes, tanks, and guns. Ammonia gas is passed over steel objects at a temperature of from 900 to 1,000 degrees F. in closed chambers. The nitrogen from the ammonia combines with the iron on the surface of the metal to form an extremely hard *case* over the inner, softer core. The interior metal retains its toughness and thus the qualities of two kinds of steel are combined in a single piece.

Another ammonia compound, ammonium chloride, is an essential ingredient of the substances used in many of the smoke boxes, grenades, and candles that set up smoke screens. These mixtures, when ignited, produce a light gray smoke of high obscuring power. A smoke box dropped behind a destroyer will burn for nine minutes or longer —long enough for a safe getaway or a maneuver to a new position from which a counterfire can be started. An accompanying chart shows many of the more important uses for ammonia, in both peace and war.

The synthesis of ammonia is not a complicated reaction. The difficulty is to hasten the reaction, for at ordinary pressures and temperatures, nitrogen and hydrogen just won't combine. Long ago, chemists discovered that when ammonia gas passed through a red-hot iron tube, it decomposed into hydrogen and nitrogen. But a close study showed that a trace of ammonia always remained. Then chemists tried reversing the process. They forced nitrogen and hydrogen

AND WHAT IT DOES



through a hot tube. Again they got a trace—but only a trace—of ammonia. They concluded that, at normal temperatures and pressures, the reaction came into equilibrium; no matter where you started, you ended with a little bit of ammonia and a lot of nitrogen and hydrogen.

Next they tried the same trick under pressure. When they got up to 150 pounds pressure and 400 degrees C., the equilibrium point rose; they got nearly four percent of ammonia. At 50 atmospheres (735 pounds to the square inch) they could get 15 percent of ammonia. But the reaction was very slow unless they added a catalyst. Haber's great discovery was that iron obtained from iron-oxide granules speeded up the reaction so that it could be run commercially. All the changes since that essential discovery have concerned three things: improving the catalyst, developing equipment for the use of higher pressures, and developing a cheaper supply of hydrogen and nitrogen. Today, half a dozen processes are in use. Some rely on hydrogen obtained by breaking up water by electrolysis. Others use coke-oven gas, or "water gas," the common illuminating or cooking gas, as a source of hydrogen.

At one of the greatest of our ammonia plants, operated by the Du Pont Company in West Virginia, coke is first prepared from coal in coke ovens. Then it is placed in a converter, and air and steam are alternately introduced. Four gases are thus formed. The steam combines with the carbon of the coke to form carbon monoxide and hydrogen. The oxygen of the air likewise combines with the coke-carbon to form carbon dioxide. This leaves the nitrogen of the air as a fourth gas in the mixture.

Since the four gases are intermixed in this first stage of the process, the problem is to separate the carbon monoxide and carbon dioxide, which are not needed for ammonia production, from the essential hydrogen and nitrogen. The other gases are, however, used in the making of other products. A little sulphur also is present in the coke and carries over in the gas mixture. This must be removed so that it will not contaminate and ruin the catalyst later on. By an ingenious process the sulphur not only is withdrawn but is obtained as a very finely divided paste, especially useful as a fungicide.

To remove the carbon monoxide, the pressure is stepped up to 300 or 400 pounds per square inch and the mixture is treated with steam in the presence of a catalyst in a converting chamber. The carbon monoxide

picks up an extra atom of oxygen from the water and becomes carbon dioxide, liberating more hydrogen. Instead of four gases, there are now three.

Carbon dioxide is removed through the use of a novel system possible because the plant is in a deep valley alongside a steep mountain. The carbon dioxide is dissolved in water under pressure, and the water is then pumped to a tank on top of the hill. Here, at atmospheric pressure, the carbon dioxide bubbles out of solution just as it does out of ordinary soda water when the pressure is released. The purified water then flows down the mountain and back to the scrubber, where it picks up more carbon dioxide. The pressure is maintained at the scrubber, at the bottom of the hill, by the hydraulic head of water. Thus only a minimum of power is needed to circulate the water through the system.

Now, at last, the actual ammonia-making step is ready to begin. The mixed gases are first compressed to about 10,000 or 12,000 pounds per square inch. They are then forced into a converter made of special alloy steel and capable of withstanding the unusual combination of heat (500 degrees C.) and pressure. Within the converter, the catalyst is piled over a series of baffles so arranged that the gas must take a long route through the material. This insures the highest possible degree of conversion in the shortest time. The catalyst consists of granules of reduced iron oxide with a small admixture of other materials, such as aluminum oxide, called "promoters" because they increase the activity of the catalyst. The first hydrogen that passes through the converter burns away the iron oxide, leaving pure iron granules. These become extremely porous, thus providing a maximum surface for contact with the gases.

This catalytic converter is the heart of the synthetic-ammonia process. Into it go hydrogen and nitrogen in proper proportions. Out of it comes ammonia gas, which can be cooled and compressed to liquid ammonia. At the Du Pont plant, the ammonia does its own cooling. As it comes out of the converter, it is piped to a large, insulated spherical tank. A continuous pump takes the ammonia vapor from the top of this tank and compresses it back into the liquid state, after which it is again forced back into the sphere. Under these conditions, the liquid ammonia is maintained at pressures only a little greater than that of the outside air. Its temperature, however, is kept near its normal boiling point, —28 degrees F. For shipment, ammonia is pumped into specially constructed, cork-insulated tank cars.

The most familiar uses of ammonia consume only a small fraction of the total annual production. Spirits of ammonia in the medicine chest and ammonia dissolved in water for cleaning purposes are the most common everyday uses. Ice plants, breweries, cold-storage houses, and industrial plants use ammonia for refrigeration. Household refrigerators commonly use other liquids, which may not always be as efficient but which operate at lower pressures and are safer in case of a break in the coils. Along with chlorine, ammonia is used by many cities for water purification, the combination having proved more effective than chlorine alone.

One compound of ammonia, ammonium

AMMONIA TAKES NEW ROLE

YOUR clothing, draperies, upholstery fabrics, and bed coverings can now be made fire-resistant and safe through the use of a new compound of ammonia—ammonium sulphamate—one of the latest developments of this important chemical. Treatment is as easy as washing clothes, and the fire-retardant solution can be made simply by dissolving ammonium sulphamate (not to be confused with the sulphate) in plain water at the rate of one pound in one gallon.

Workers in war industries may treat their clothing, from coveralls and hats to shoes and socks, with the solution and be prepared for emergencies. In the home, the treatment can extend to children's and adults' clothing, blankets, linens, kitchen towels, ironing-board covers, all upholsteries, and both heavy and filmy drapes. Although materials so treated may be damaged by fire, they are protected against bursting into flame and spreading a blaze.

Articles to be treated should first be washed or otherwise cleaned and then repaired. For a war worker who may be exposed to flames in the course of a day's work, some alterations might be made profitably, especially in coveralls, which should not have cuffs, outside hems, or open pockets that could catch flying embers. Wash goods are soaked in the ammonium sulphamate solution until saturated, with a wetting agent such as soap or a soapless cleanser added to help penetration if the material is new. The articles are then dried, and pressed if desired, like ordinary washing.

Nonwashable fabrics are hung on a clothesline and sprayed or brushed thoroughly. They should remain hanging until dry. Gloves, shoes, hats, and the like may be dipped in the solution, and should be dried in the shade, away from heat.

carbonate, is used for making the sponge-rubber cushions once used for autos and now employed for a number of military purposes. The heat of vulcanization turns this chemical into ammonia gas and carbon dioxide gas, inflating the rubber into a spongy, porous mass and causing it to rise and fill the mold.

A strange use of ammonia is as a source of hydrogen. It may seem odd that, after all the trouble the ammonia makers take to get hydrogen into their synthetic ammonia, they should turn around and offer the produce as a source of hydrogen. The answer lies in the ease with which it can be transported. One standard, 100-pound cylinder of ammonia yields 3,400 cubic feet of hydrogen, which would require 17 cylinders if it were to be shipped in the ordinary way.

More important than any of these uses, except the war uses today, is the conversion of ammonia into fertilizers. Synthetic ammonia has materially reduced the cost of fertilizers while encouraging a vast increase in the amount used by American farmers. Many of the new synthetic materials employ ammonia directly or indirectly, particularly the urea plastics, nylon and Lucite. One of the newest uses for ammonia products is described below.

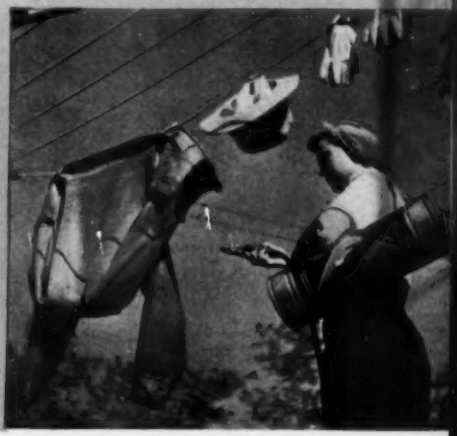
IN A COMPOUND FOR MAKING FABRICS FIRE-RESISTANT

Shirts and other washable articles may be immersed in a solution of ammonium sulphamate to be made fire-resistant

Other articles, such as the leather jacket above, are brushed with the solution. They should be covered thoroughly inside and out

Rugs and similar furnishings are sprayed as below and allowed to dry in the shade

Nonwashable clothing also may be sprayed on a line. Be careful to reach all the seams



Detroit Moves into Your Home Town for Help in **Building Guns**

SHOPS BY THE THOUSANDS THROUGHOUT INDUSTRIAL AMERICA FEED PARTS TO THE GREAT ARSENAL CITY

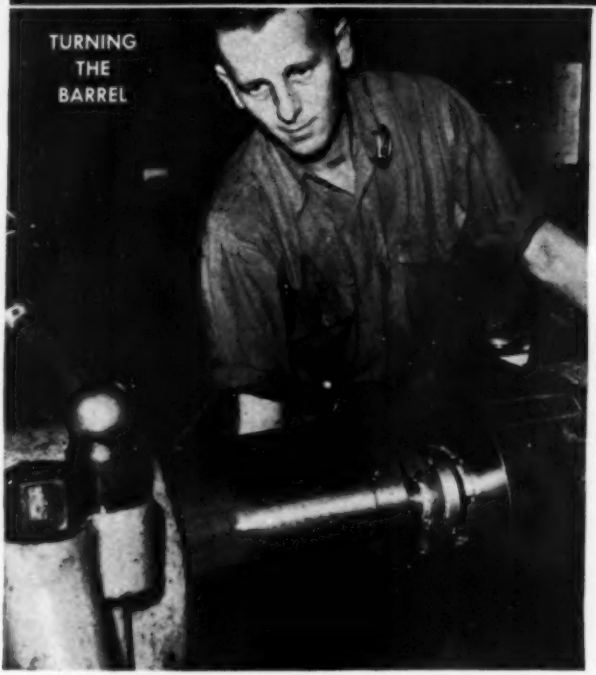
By HICKMAN POWELL

Photographs by H. Marple

THIS war has so speeded up and complicated our lives that we tend more and more to do our thinking and talking in shorthand, in catch phrases. "Pearl Harbor," for instance, has become a national symbol for initial frustration, humiliation, and determination to exact satisfaction. And since Pearl Harbor we have come to talk of "Detroit" as a symbol for what a punster might call conversion and national salvation.

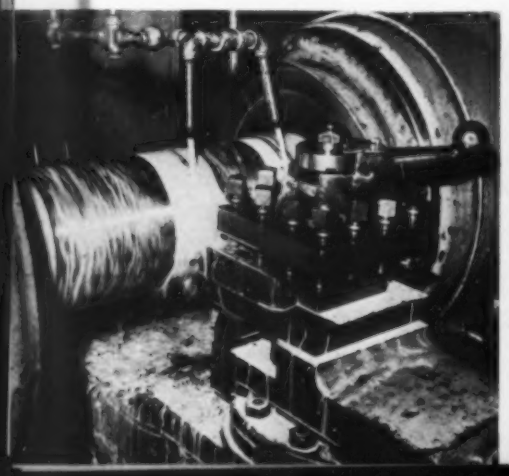
The Detroit we speak of is, of course, the entire automotive manufacturing industry, converted to war production. But unless we are careful, we are likely to think of it as one city — especially since censorship frowns on the identification of towns where munitions are made. Actually, if you live anywhere in the Northern industrial area from east of the Alleghenies to the Mississippi basin, the odds are that some segment of De-

HOW DETROIT TURNS OUT

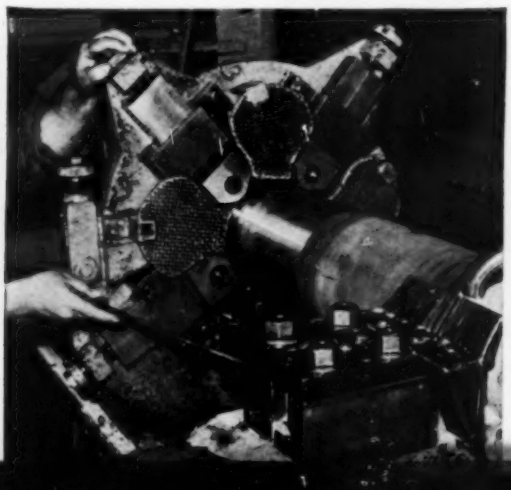


1 Rough-forged extrusions more than nine feet long are the basis of the 75-mm. cannon used on our M-4 tanks. They reach the Olds plant with a hole already through the center, and are checked first for straightness of forging and hole

2 Holes are bored in the ends of the tubes on a huge Lehman lathe, and expanding centers are set for the first turning operations, one of which (below) is turning a steady-rest position

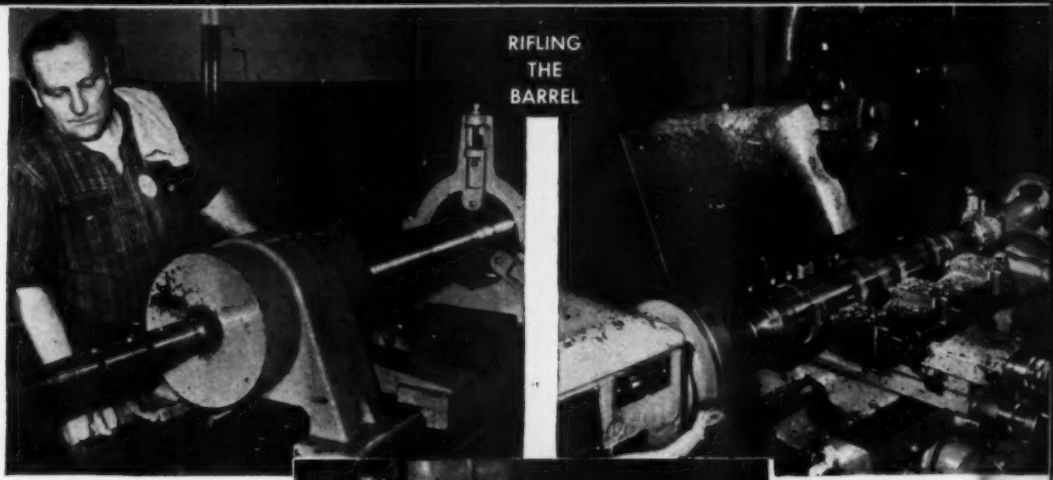


3 This steady rest helps in holding the long tube straight for the turning operations that come next. It is shown, below, as it is chucked on the lathe for the first rough-turning of the big barrel



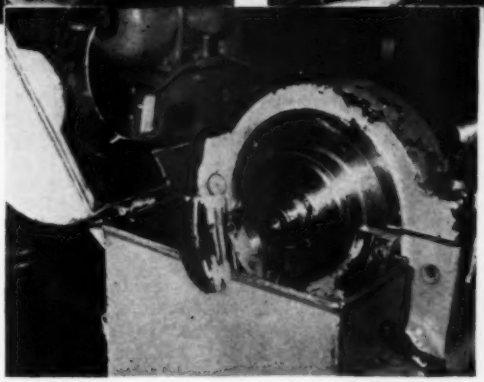
to Smash the Axis

THE 75-MILLIMETER CANNON



RIFLING THE BARREL

4 On a steel backbone holding two cutting tools, a self-centering boring head is built up of two half cylinders of Babbitt metal. These are turned .002 inch smaller than the bore to be cut in the gun barrel

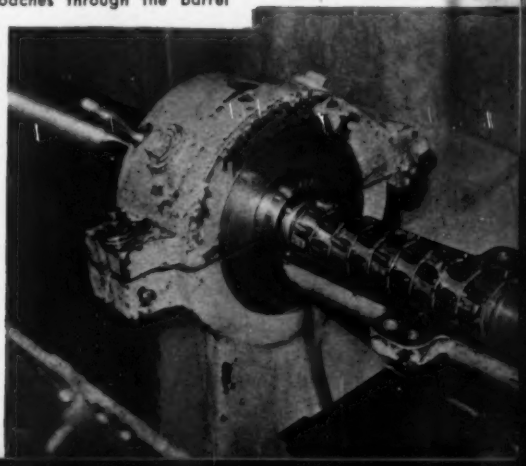


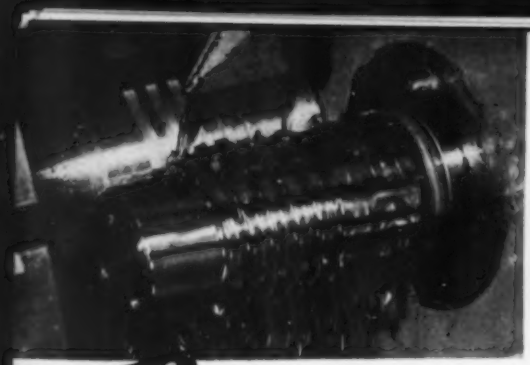
5 Wooden plugs are inserted in the boring head and turned to a diameter .010 inch larger than that of the gun bore. Centering is done by their pressure. Plugs are renewed for each boring operation

6 Rifling is cut inside the bore after completion of boring, reaming, and honing. This is done by forcing a series of 18 broaches through the barrel

7 Ordnance inspectors examine the rifling in detail with the aid of a boroscope, which is an instrument having an arrangement of lenses, a light, and a mirror to permit close scrutiny of all points in the barrel

8 Any imperfections that are discovered in the rifling can be corrected by careful honing with a bar on which dozens of honing stones are set in the spiral form shown in the photograph below





MAKING THE BREECH

One of the most precise operations in making the 75-mm. gun is in turning the threads (left above) by which it is later attached to the breech ring. Simultaneous milling of the two sides of the breech-ring piece from a rough forging is shown at the right

Machine operations have reduced the time on the breech ring to one tenth of that formerly required and cut hand-finishing to a minimum

Breech ring and tube threads are both accurately milled, and when they are screwed together the ring is in precise relation to the tube markings

troit is in your own home town—fabricating some precision part for a complex item that will become merely part of a complex fighting machine.

The city of Detroit is the nerve center, the command post, of a vast, far-flung organization of brains and skill. It has become even more so since, a few months ago, the Army Ordnance Department at Washington split off all its offices having to do with tanks and transport equipment and set up the Tank Automotive Center in Detroit with a military and civilian personnel of 4,000.

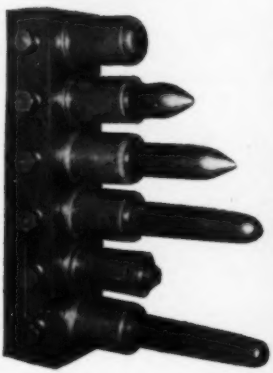
But the command post is not the best place to watch a war, and neither is one of the big spectacular war plants the best place to understand production. Close to Detroit, for instance, is the Detroit Tank Arsenal, as exciting a war-industry sight as you might hope to see. Here are acres of machines making transmission gears. Through other acres the overhead cranes lightly swing great cast turrets and welded hulls from station to station, while workmen machine their precision parts. And on the final assembly line there suddenly appears, as if by magic, a host of other parts —guns, engines, tracks, and

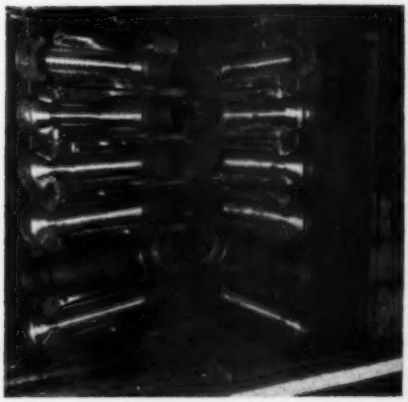
Acres of space are devoted to precision work on the big 75, but the final assembly line, at left, is only 75 feet long—a departure from the old complex assembly lines for automobiles

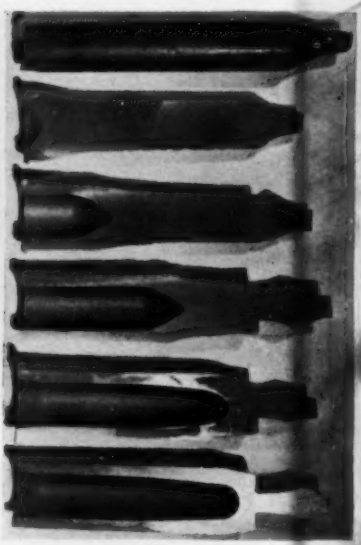
MAKING THE SHELL

Billets for the shells are heated in a battery of induction furnaces to about 2,350 degrees in just under 2½ minutes

Tongs hold the billet as it is removed from the furnace and swung, still hot, into a punching machine for shaping





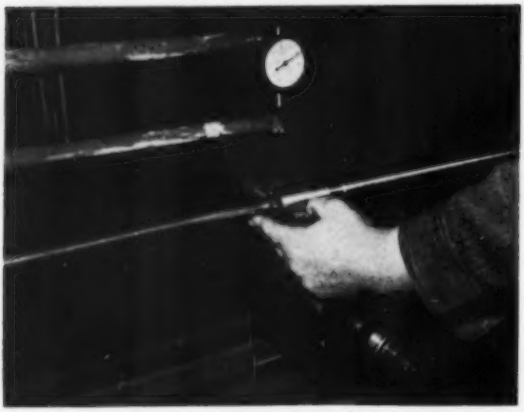


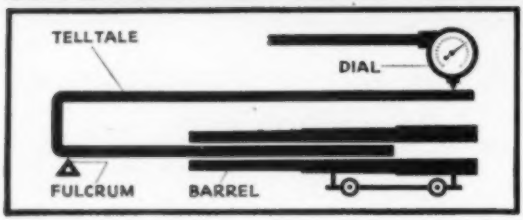
Each machine has a block of punching dies (left) and female dies (above) that carry a billet through the various changes shown at the right. The billet, starting as an 18-inch blank 2⅝ inches in diameter, becomes an 11¼-inch shell with a 3⅛-inch outside diameter and a 2⅛-inch cavity. Metal clipped off goes into another small forging. The nose of the shell is closed in a cold press, and machining is then completed

all the secret inner workings of the turret.

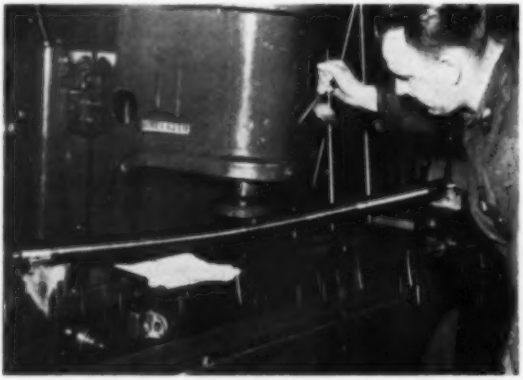
It is an exciting experience to watch these great, complex engines of war take shape and roar off to the proving grounds; but you can't understand a river by looking at its mouth. It was with some such thought in mind that I recently got on a train in Detroit and rode two hours to take a close look at what they were doing at the Olds Works of General Motors.

Olds is a specialist in weapons, in stings for the hornet, and its various units cover better than 100 acres. It makes shell casings for the 75's and 105's by the millions. It turns out a flood of 20-mm. cannon for Mustangs and Spitfires, 37-mm. cannon for Airacobras, and 75-mm. guns for M-4 tanks. You get some idea of the rate of production from the continual, intermittent roar of aircraft cannon in underground testing tunnels.





Straightness of barrels is tested after turning and before final boring with the telltale, a tool-steel lever having a rotating wheel on the end placed in the barrel. Any bend shows up on a dial as the wheel runs around inside the tube



When a bend is found, the imperfect barrel is slid under a press and straightened to within .003 inch before reaming and rifling is begun. Testing and straightening operations shown above are being done on a 20-mm. cannon for a plane

Olds first got into war industry in 1940, turning over its new No. 1 forge plant to the manufacture of shells. As indicated in some of the pictures accompanying this article, this plant is itself something of a marvel of mass production. Olds was so successful that it is now operating five great shell forges in Michigan, Missouri, and Wisconsin, turning out a fantastic number of millions of projectiles. But forging steel shells is a relatively simple procedure. It was in the precision work of making guns that Olds met the real test.

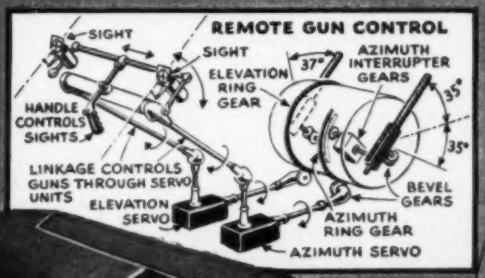
In April, 1941, the Olds Works first tackled the delicate art of the gunsmith, and six months later, just a few weeks before Pearl Harbor, the first guns came off the assembly line. They were the M-2 version of the 20-mm. cannon, based on the British Hispano Suiza, for installation in the leading edge of a pursuit plane's wing. As automatic guns go, this is relatively simple, for it needs no aiming mechanism; but its 115 pounds of steel include 127 parts, each of which must be machined to the gnat's eyebrow. It must fire a burst at an average of 600 rounds a minute, and never jam.

To machine that many parts in mass production would have taken a vast new plant if Olds had tackled the job alone. Instead, the company called in 500 representatives of outside shops, showed them blueprints, specifications, and models of the 127 parts, and asked them what they could make. The upshot was that 124 of the 127 parts were farmed out to other shops—many of which had never tackled anything so precise and complex before. Olds set up trouble-shooting teams of technical and production men and *(Continued on page 198)*

New Nazi Fighter-Bomber

AIMS REAR GUNS BY REMOTE CONTROL

LATEST addition to the Luftwaffe is the Messerschmitt 210 A-1, a fast, two-place fighter-bomber carrying six guns, 900 pounds of armor, and considered one of the most dangerous weapons of the air. Descended from the well-known Me-110, it employs a radical change in design in its rear armament. Two 13-mm. machine guns, believed to be modeled after our own .50 caliber Colt Browning guns, are mounted at the sides of the fuselage on an electrically driven drum whose operation is diagrammed directly below. When aimed in a line parallel within two degrees of the axis of the plane, both guns can be fired simultaneously. When it is necessary to aim at a greater angle of azimuth, the gun on the side opposite the target halts at a certain point in the swing and automatically ceases firing.



BULLET-PROOF GLASS

TWO DRUM-MOUNTED 13-MM. MACHINE GUNS

ELEVATION SERVO

SYNTHETIC-RUBBER OIL TANK

ARMOR

DIVING BRAKES (ON WING TOP AND BOTTOM)

PILOT—BOMB AIMER—FRONT GUNNER

BULLETPROOF WINDSHIELD

20-MM. CANNON (2)

7.9-MM. MACHINE GUN (2)

FLEXIBLE, SELF-SEALING, SYNTHETIC-RUBBER FUEL TANKS

SHOCK ABSORBERS OF NOVEL SIMPLIFIED MOUNTING OF 1,270-HP. INVERTED ENGINE

FRONT ARMOR

BOMB LEAVING BOMB BAY

"PIGGY-BACK" TRAINING of pilots for P-38 Lockheed Lightning interceptors has cut the index of accidents to fledgling flyers from 6.5 to 1.5. By removing part of the radio equipment, room is made for the student to squat behind the instructor in the single-seater plane. After watching the veteran fly the powerful ship, he is better prepared to go ahead on his own. In the training flight, he rests his chin on the instructor's shoulder.

DESTROYER ESCORTS sleek little craft representing a cross between the British corvette and the traditional destroyer, have joined the U.S. naval vessels engaged in the Battle of the Atlantic. Specially designed for the job of convoying cargo ships through submarine-infested waters, the "DE" boats have a displacement of 1,300 tons, a water-line length of about 300 feet, and a beam of 35 to 36 feet. Armament includes torpedoes, depth charges, antiaircraft guns, and naval cannon large enough to enable them to shoot it out with surfaced subs. They will relieve bigger destroyers for combat duty with the fleet.

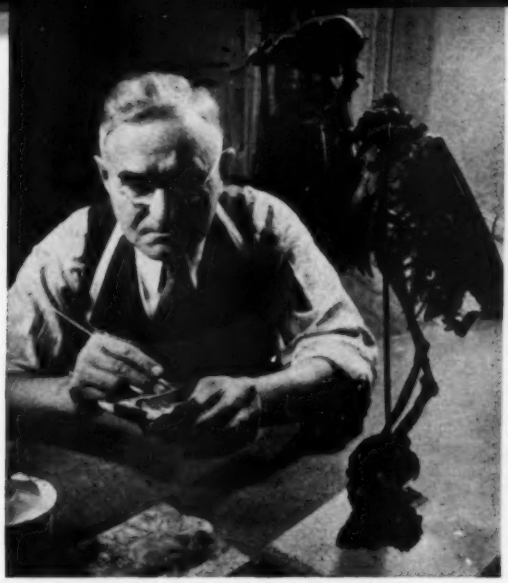
"THE BAZOOKA" is the name our soldiers have given their newest antitank weapon. Developed after long experiment by the Ordnance Department, the new tank killer is light enough to be carried in a jeep or by two soldiers at a dog-trot. Its high-explosive projectile makes it an effective arm for raiding and reconnaissance groups, as well as for defensive use by drivers, orderlies, and mess personnel. Two men handle it, one loading the piece while the other aims and fires.

CRAFTSMAN in BONE

Assembles Skeletons of Prehistoric Birds

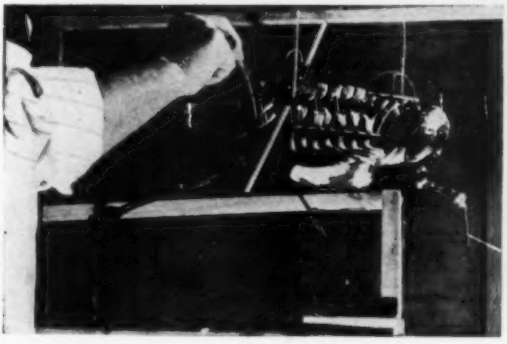
MASTER of one of the most difficult of all handicrafts is Eugene J. Fischer, osteologist of the Los Angeles County Museum, who applies his skill to reconstructing the skeletons of prehistoric birds. Often working with only fragmentary bones, Fischer matches the parts, repairs those that are damaged, and reconstructs those that are missing. The authentic bones with which he works come from an amazing storehouse of natural history—the La Brea tar pits, where prehistoric birds were trapped when their feet touched the sticky substance. Besides bones of 50 mammal species, the pits have yielded skeleton parts of 110 kinds of birds, of which 18 are extinct. Bones are classified by Dr. Hildegarde Howard, curator of avian paleontology.

Photographs by A. Eriss



Under the wide eye of a *Hypomorphnus fragilis* skeleton, E. J. Fischer rebuilds part of a skull with papier mâché

Classifying the bones and making a record of those used in mountings is done by Dr. Hildegarde Howard, curator



Parts are held in place by strings tied to a frame. Here an eagle's skeleton is shown in the process of assembly

Finishing touches on this *Spizaëtus grinnelli* specimen are made with a paintbrush. At the right is a smaller eagle's skeleton

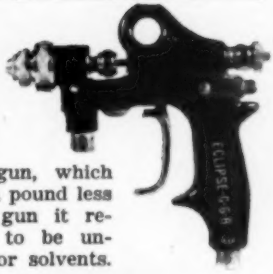
NEW Tools

FLUORESCENT LIGHTING from a small tube about five inches long is the feature of this new magnifying stand carrying a five-inch lens. The stand is brought out by The Stanley Works, of New Britain, Conn., in both hand and bench models, and is designed for use by machinists, tool makers, and inspectors.

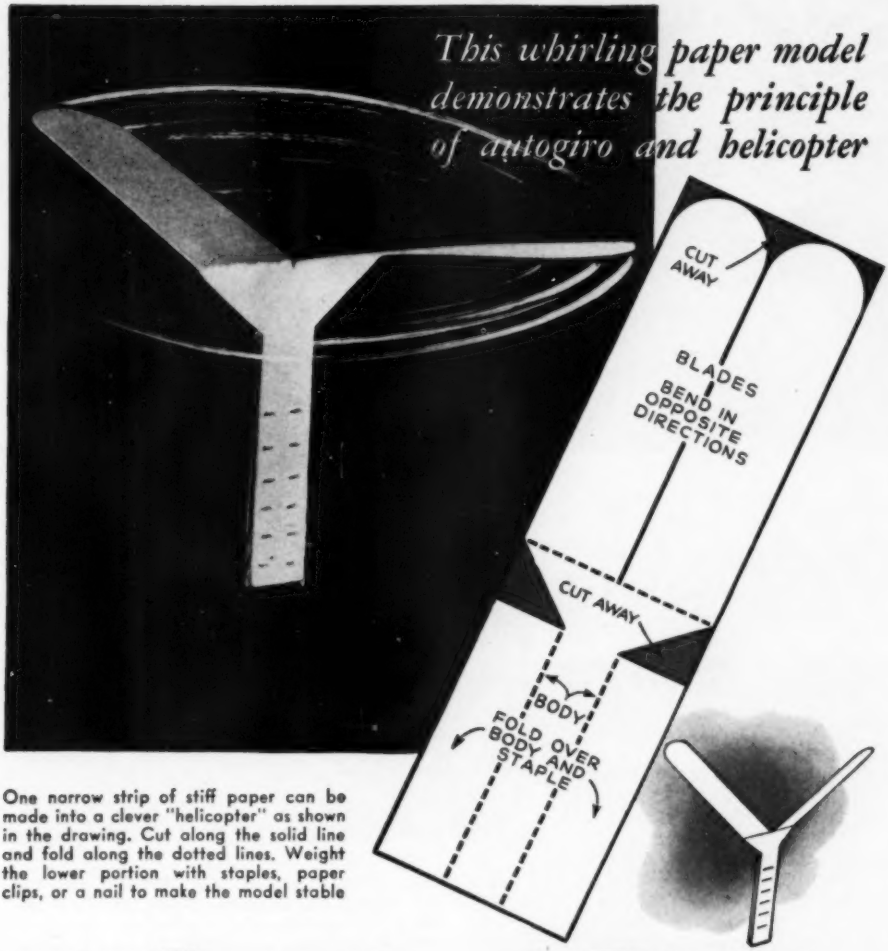
BROACH SHARPENING is now done more quickly with a machine whose grinding head can be adjusted to any required angle. Made by the Colonial Broach Co., of Newark, the machine can handle flat broaches 65 inches long between end teeth, and round broaches up to 72 inches between centers.

DUST COLLECTING, to protect both the workman and the material being ground or polished, is done by a current of air which is sucked down through the grille of this workbench. Made by the Wolverine Equipment Co., of Cambridge, Mass., the collector filters the dust-laden air and returns it to the workshop. No pipe connections are required, as the unit is entirely self-contained.

SPRAY GUNS made of plastic are being manufactured by the Eclipse Air Brush Co., of Newark. Bakelite is used in the body of each gun, which weighs a quarter of a pound less than the aluminum gun it replaces, and is said to be unaffected by thinners or solvents.



This whirling paper model demonstrates the principle of autogiro and helicopter



One narrow strip of stiff paper can be made into a clever "helicopter" as shown in the drawing. Cut along the solid line and fold along the dotted lines. Weight the lower portion with staples, paper clips, or a nail to make the model stable

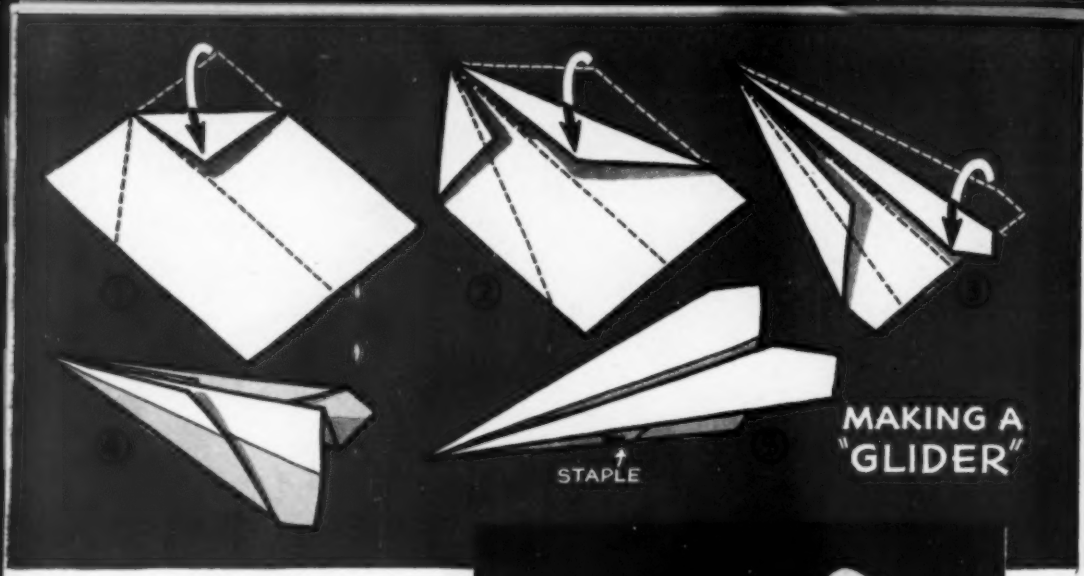
You Can Learn Secrets of Flight from Models Made with Scissors and Paper

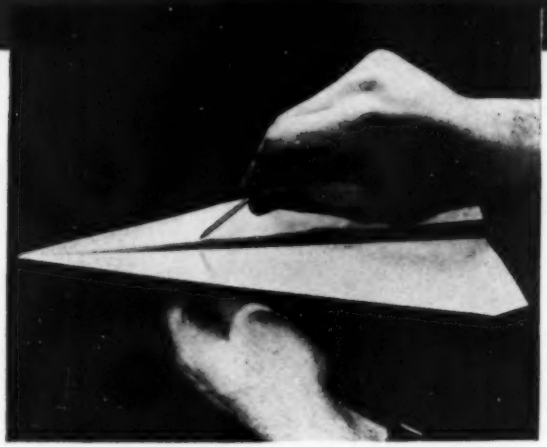
By LOUIS TEICHMAN

SIMPLE paper airplanes that you can build in a few minutes can serve as valuable models in illustrating many fundamental principles of aeronautics. With them you can see in action characteristic features of such designs as the airplane, glider, flying wing, helicopter, and autogiro. The drawings on this and the following pages show the steps in making three basic models—the "helicopter," "glider," and "flying wing."

With models like these, you can study the effect of wing loading, the reason for dihedral, the operation of ailerons, rudders, and elevators, the importance of correctly locating the center of gravity, the use of wing flaps, the effect of increasing wing camber, and other aerodynamic principles that are necessary for a sound understanding of the nature of flight.

You may drop, for instance, the "helicopter" from a height and see the rotating blades retard its descent. The blades of a true helicopter are power-driven, and though your model might be more accurately called





These are the steps in making a "glider" from a single sheet of paper. After the model has been folded, a staple or paper clip will hold it firmly. At right, the nail is being tried to determine proper location for a model's center of gravity

a "gyroplane," of which the autogiro is the most familiar example, its downward movement is that of a helicopter, power off, windmilling to a glide landing.

A plane's speed is governed in part by wing loading, which is its weight divided by the surface area of its wings. The greater this wing loading is, the greater the speed must be to keep the plane in the air. Examples are the light weight and large wings (low wing loading) of a slow primary trainer and the relatively small wings and greater weight (high wing loading) of a fighter with its oversize, high-powered engine and burden of guns, ammunition, armor, and fuel.

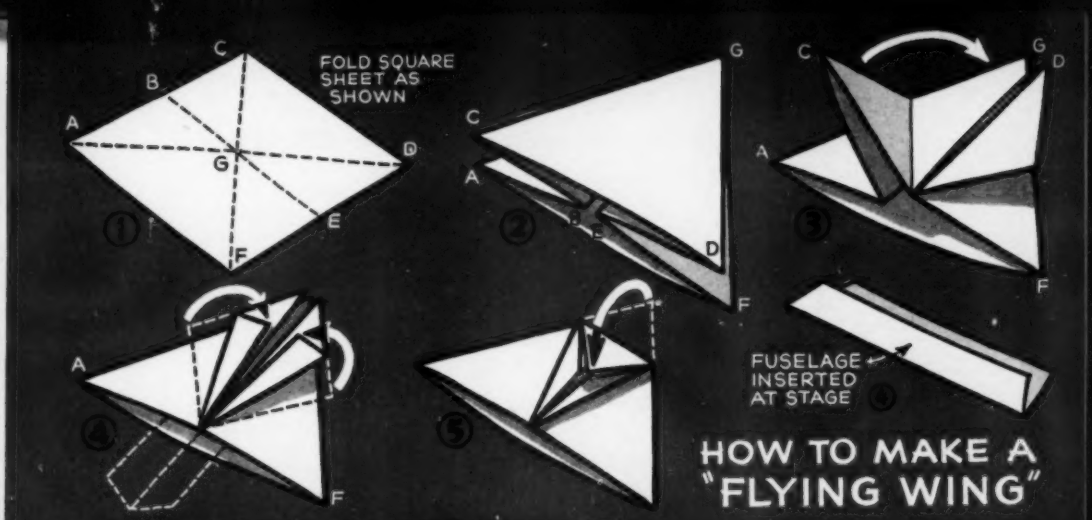
Make several glider models of the same size and shape, one of onionskin or tissue paper and one each using one, two, and three thicknesses of typewriting paper, for a study of the effect of changing weight for the same wing area. Then make two more models of the same kind of paper, one with wings as in the drawing and the other with the last fold shifted to form a wider wing. The model with the larger wing surface (lower wing loading) will travel considerably more slowly.

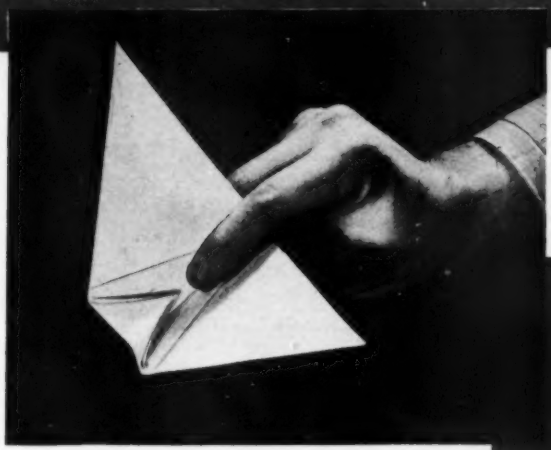
Dihedral—mounting wings on a fuselage so that they tilt slightly upward—helps to produce lateral stability. Fold the wings of a glider downward, and it will very likely roll over and over in flight, but if the wings are folded up and away from the fuselage, they will counteract this tendency and keep the model flying level.

The location of the center of gravity contributes to longitudinal stability. Mount a small nail or brad between the wings of a glider, keeping it in place with a staple, and watch how it affects the flight when shifted back and forth. You will find that the model flies well only when its center of gravity remains within certain limits in relation to the wings.

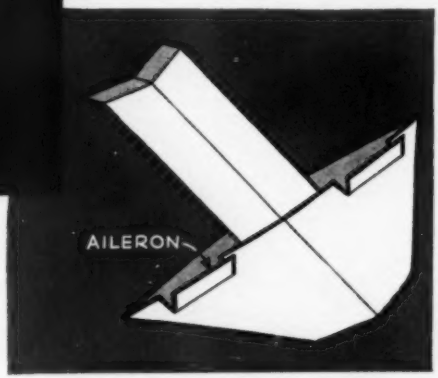
Directional stability—ability to fly in a straight line—depends on the fuselage and fin. Comparison of the paths of flights of the glider model, which has a relatively long fuselage, and the flying wing, which has none, offers a good example.

For ailerons, bend the rear edge of one glider wing up and the other down, and the model will fly in a circle. If the bends are reversed, the rotation will be in the opposite direction. Bend both of the rear edges up or





By carefully following the letters in these drawings, you can fold a sheet of paper into a "flying wing" without much difficulty. For some demonstrations a fuselage will be needed, while for some others ailerons may be made, as below



down to show the effect of elevators. In the former case, the wind against the upturned surfaces will cause the tail to go down and the nose to rise, while the glider will dive if the edges are bent down.

To study the effect of a rudder, bend the tail end of the fuselage of another glider to the left. Your model will go into a spin toward that side. This can be counteracted by aileron control—bending the rear of the right wing up and that of the left wing down. A few trials may be necessary to get the proper correction to make the model turn evenly toward the left. In this test, the aileron controls are used opposite to the way they would be used on a plane because your rudder is *under* the wings.

The directional stability of your flying wing can be improved by adding a boom, or fuselage, as shown in the drawings. Bending the end of this boom upward will help still more. Make several flying wings as nearly alike as possible and provide each with the inserted fuselage. Cement together the upper and lower surfaces of one model's wing so that it lies perfectly flat, and separate the wing of another by pushing in at the ends. The wing with the curved surfaces (camber) should stay in the air longer and fly more slowly than the flat-wing model. Cut flaps in the lower surface of the wing of a third flying-wing model and bend them down. This should make the model sail more smoothly than one which has not been treated in this way.

With a little experimenting, you can add to these ideas and demonstrate many other aeronautical principles, including such spectacular feats as loops, rolls, and other aerobatics.

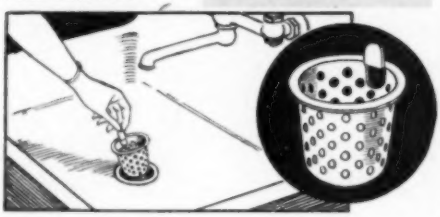
What the Inventors Are Doing

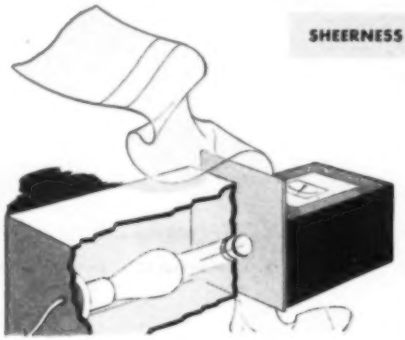
HUMAN SPIDER'S WEB ADJUSTABLE tackle that suspends a painter or window washer from a roof and allows free movement over a large area has been invented by Rox D. Penlon, of San Francisco. Pulleys are hooked over the coping and to a safety belt. The worker moves along the wall by manipulating the rope lengths.

ORDINARY coat hangers may be turned into tie racks with the simple addition of an adapter devised by H. S. Lazarus, of St. Louis, Mo. This adapter is a stiff board with a half dozen circular holes that hold individual neckties and keep them from wrinkling or sliding together. A hanger is attached by pushing its ends through vertical slots.

DRAINS of kitchen sinks may be kept free-running by using disposable strainers designed by Isabelle R. Platte, of Waterville, Conn. These strainers resemble perforated paper cups and are shaped to fit snugly within a drain hole. A tab inside the upper rim provides a convenient handle for removing one when it becomes clogged with refuse, to replace it with another.

DISPOSABLE STRAINER

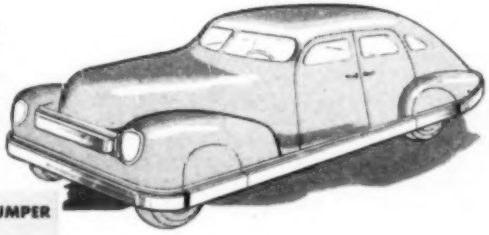




SHEERNESS METER

HOSIERY and other delicate fabrics may be measured for relative sheerness by light passing through them in an instrument patented by Jerome Barney, of Bethlehem, Pa. A concentrated light beam of known intensity is projected on the fabric, while a standard light meter converts to electric current and registers on a dial that part of the light that passes through. Results are instantaneous and constant in contrast to the tediousness of counting threads and loops through a magnifying glass with possible differences in visual judgment.

SIDESWIPE protection as well as that for front and rear-end collisions is provided by a shock absorber developed by Owen D. Premo, of Muskegon Heights, Mich. It acts as a bumper going all the way around a car. Sections at the wheels are removable.



ALL-AROUND BUMPER

A single shot from the three-inch high-velocity gun on this M-10 self-propelled mount will disable any tank at 2,500 yards or more. The M-10 is faster than most tanks

Big Guns That Stalk Their Targets

U. S. ORDNANCE ENGINEERS TAUGHT THE GERMANS HOW TO PUT CANNON ON MECHANIZED MOUNTS . . . AND NOW WE'RE BEATING THEM AT BUILDING THESE "SURPRISE" WEAPONS

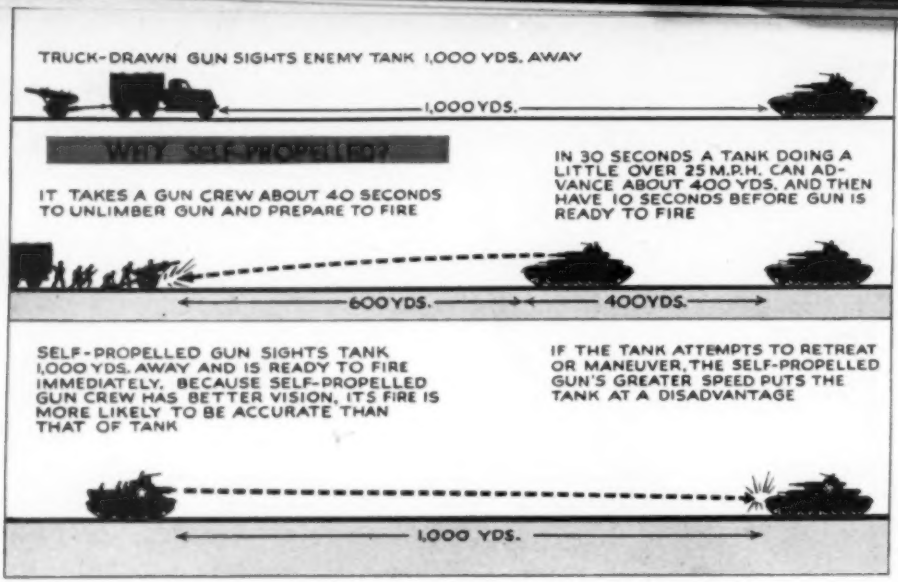
By ARTHUR GRAHAME

OUR self-propelled artillery, first spotlighted by the outstanding performance of our mechanized 105-millimeter gun-howitzers on their initial appearance in the fighting on the North African desert, is going to play an increasingly important part in the winning of the war.

Many Americans who read of how our M-7's, lend-leased to the British Eighth Army, blasted Rommel's Afrika Korps tanks into fire-blackened hulks in the Battle of El Alamein thought back to the early days of the current struggle, remembered that the Nazis had used self-propelled guns effectively in their Polish, French, and Balkan campaigns, and took it for granted that mounting cannon on self-propelled carriages instead of hauling them behind horses, trucks, or tractors was a German innovation which we successfully copied.

But self-propelled artillery most emphatically is *not* a German innovation. It was pioneered by the U. S. Army over a quarter century ago.

Our Army Ordnance Department built the world's first self-propelled gun. During World War I it built a considerable number in various calibers. *(Continued on page 120)*

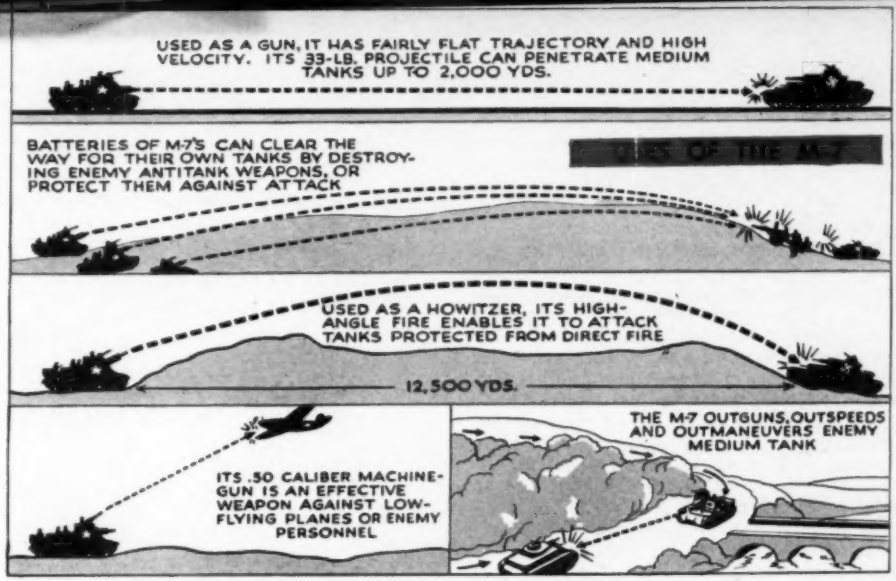

TRUCK-DRAWN GUN SIGHTS ENEMY TANK 1,000 YDS. AWAY
1,000 YDS.
WHY SELF-PROPELLED?
IT TAKES A GUN CREW ABOUT 40 SECONDS TO UNLIMBER GUN AND PREPARE TO FIRE
IN 30 SECONDS A TANK DOING A LITTLE OVER 25 M.P.H. CAN ADVANCE ABOUT 400 YDS. AND THEN HAVE 10 SECONDS BEFORE GUN IS READY TO FIRE
600 YDS.
400 YDS.
SELF-PROPELLED GUN SIGHTS TANK 1,000 YDS. AWAY AND IS READY TO FIRE IMMEDIATELY. BECAUSE SELF-PROPELLED GUN CREW HAS BETTER VISION, ITS FIRE IS MORE LIKELY TO BE ACCURATE THAN THAT OF TANK
IF THE TANK ATTEMPTS TO RETREAT OR MANEUVER, THE SELF-PROPELLED GUN'S GREATER SPEED PUTS THE TANK AT A DISADVANTAGE
1,000 YDS.

Self-propelled guns bear out the theory that the way to beat a tank is to beat it to the punch and to do so with a heavier punch. Our latest tank destroyers can do just that. With their guns pointing forward, they are ready to fire at any moment and often can finish the job while out of enemy range

HOW MODERN SELF-PROPELLED WEAPONS NOW PERFORM

Mounted on a ¾-ton truck body, the 37-mm. gun at the left can be put into action in a hurry, and can get away fast. No time is lost wheeling the piece into position and unlimbering it from the truck, as in the case of a towed weapon

Below is shown the "37" (at left) beside the three-inch high-velocity gun, both on towed carriages. The three-inch is approximately the same caliber as the "75," but has a longer barrel which helps to give it its terrific punching power


USED AS A GUN, IT HAS FAIRLY FLAT TRAJECTORY AND HIGH VELOCITY. ITS 33-LB. PROJECTILE CAN PENETRATE MEDIUM TANKS UP TO 2,000 YDS.
BATTERIES OF M-7'S CAN CLEAR THE WAY FOR THEIR OWN TANKS BY DESTROYING ENEMY ANTITANK WEAPONS, OR PROTECT THEM AGAINST ATTACK
USED AS A HOWITZER, ITS HIGH-ANGLE FIRE ENABLES IT TO ATTACK TANKS PROTECTED FROM DIRECT FIRE
12,500 YDS.
ITS .50 CALIBER MACHINE-GUN IS AN EFFECTIVE WEAPON AGAINST LOW-FLYING PLANES OR ENEMY PERSONNEL
THE M-7 OUTGUNS, OUTSPEEDS AND OUTMANEUVERS ENEMY MEDIUM TANK

Miscalled both a tank and a tank destroyer, our M-7 105-mm. self-propelled gun-howitzer is really a mechanized support gun for armored divisions and an ideal all-purpose weapon. Nicknamed "The Priest" by the British because of its pulpit-like machine-gun mount, it helped to blow Rommel out of Egypt

THE TASKS OF FIELD PIECES THAT MUST BE TOWED

These are the shells that the two types of guns spit whether they are mounted on self-propelled or towed carriages. The huge propelling charge for the larger weapon will drive its projectile through the heaviest armor at long range

And here is the hard-hitting, high-velocity three-inch gun mounted on the M-10 motor carriage. Ready to fire at drop of a hat, it packs a wallop that gives it a substantial edge over the Nazis' touted "88." Full tracks take it anywhere, fast

Continued

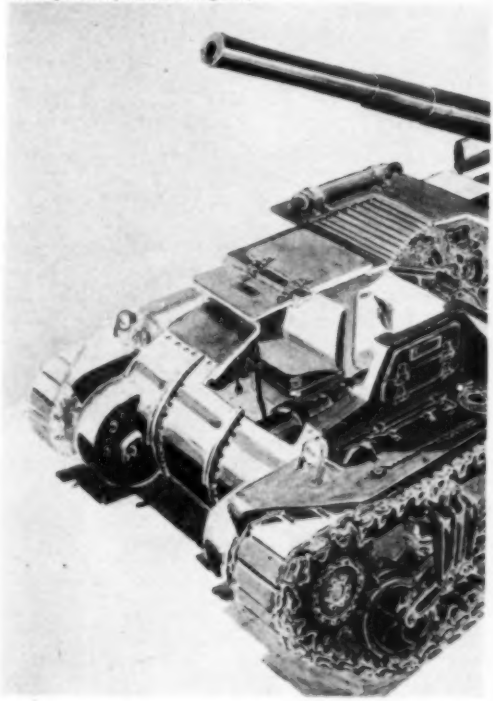
After that war it continued the development with such success that in 1920 the Westervelt Board of experts appointed to redesign all our Army artillery weapons reported that it had eight models of self-propelled guns of from 75-mm. to 155-mm. caliber under test or under production, and that in weapons of this type our Army was far in advance of all the others in the world.

Then, in the early 1930's, we threw away the invaluable lead which had been won by the inventiveness, ingenuity, and hard work of our Ordnance officers and the civilian automotive experts who had worked with them. The principal cause was the niggardly Congressional appropriations which made further experimenting practically impossible; between 1920 and 1933 the Army was able to spend only $2,000,000 for experimental work in all branches of mechanization, including the development of the tank. But a contributing factor was the belief held by some high-ranking artillery officers that the little money available would be better spent on the improvement of our horse and truck-drawn artillery than on the development of the newfangled self-propelled mounts which they thought would never carry a gun onto a battlefield.

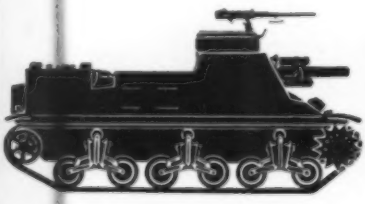
Some of the men who were busy rebuilding the military machines of Europe were better at seeing what was ahead. Especially the Germans. In the 20's Germany had only a small army and smaller means of developing it, but the German military attachés stationed in Washington evinced strong curiosity about our experiments with self-pro-

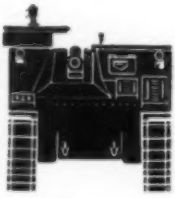
Even our longest-range fieldpiece, the mighty 155-mm. gun, has now appeared in battle on its self-propelled mount. One was being developed for it before we entered the war. Below is an artist's conception of the gun on a tank chassis

Drawing courtesy Collier's Magazine



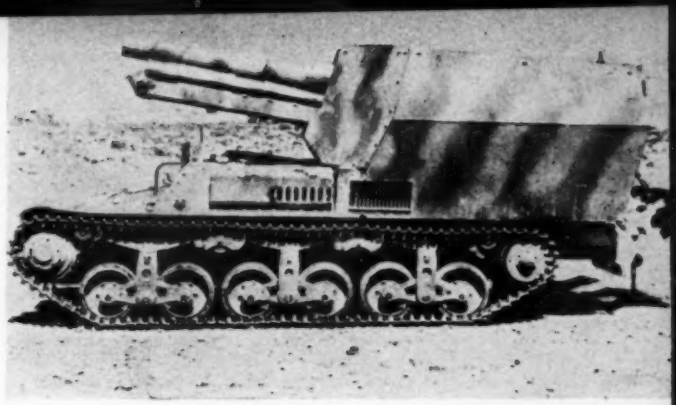
OUR NEW SELF-PROPELLED M-7 105-MM. GUN-HOWITZER

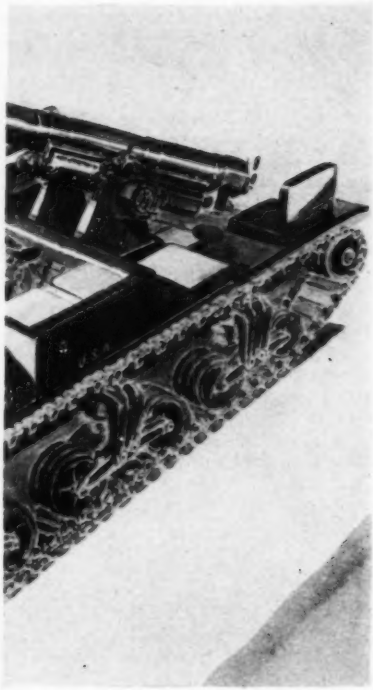


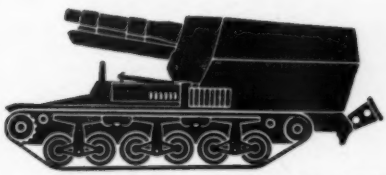


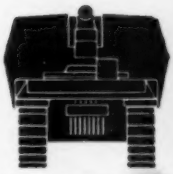
This multiple-purpose weapon is mounted on a medium-tank body and can travel 35 miles per hour. Shown at right as it is being loaded, it can be used for direct fire as an antitank gun or for a barrage, while its .50 caliber machine gun (below) is antiaircraft defense

At right is the Germans' six-inch gun mounted on a chassis made in France. This gun, in practically new condition, was captured by the British as they chased Rommel









Silhouettes from Army Orientation Course posters

pelled artillery. With our usual peacetime openhandedness, we gave them information which their own government would have guarded jealously as a vital military secret. The use they made of that information became apparent when the Nazi propaganda film "Sieg im Westen" was shown here in the spring of 1941. One of its sensational features was a self-propelled medium howitzer which was shown lurching through the streets of a French town and blasting down defended walls and buildings for the German infantrymen who followed. American officers who had been familiar with our early self-propelled gun mounts rubbed their eyes in astonishment. That Nazi self-propelled howitzer carriage was so much like our Mark VII motor carriage built in 1919 that they looked like twins.

PACKS A TERRIFIC PUNCH

Germany started this war with a long lead in self-propelled artillery, but the Nazi weapon makers haven't been able to hold their initial advantage. Open-minded tests made at the Aberdeen Proving Ground of recently captured German self-propelled guns show that they have been improved only slightly since the beginning of the war. Our Ordnance Department, making a new and late start but building on the solid foundation of the experience gained through several years of earlier development, has gone far ahead of the Germans. Right now we have the world's best self-propelled guns on the fighting lines—and, in all probability, we have more of them than the Germans have. Our excellent 105-mm. M-7's and half-track tank destroyers armed with 75-mm. high-velocity guns are only the forerunners of the American mechanized artillery might that is on the way. Already more potent self-propelled weapons are beginning to roll off Detroit's roaring assembly lines.

Before we entered World War I the fighting in France had shown the necessity for

37-MM. GUN ON ¾-TON TRUCK

This highly mobile light gun can travel faster than 55 miles per hour. The light shield provides protection for the crew against the fragments from bursting shells

mobile antiaircraft guns, and in trying to meet this need our Ordnance Department mounted a 75-mm. gun capable of high-angle fire on a White truck. This makeshift was the first self-propelled gun of which there is record. Shortly after we got into the war, 200 of them were built. A few were used in France, and some were kept in service until only a few years ago.

In 1917 our Ordnance officers, assisted by J. Walter Christie, former race driver and pioneering automotive engineer, produced the world's first real self-propelled gun—a three-inch antiaircraft gun mounted on a low-slung, four-wheeled carriage propelled by a gasoline engine. Caterpillar tracks soon replaced the wheels, and the mount proved highly satisfactory.

Shortly after we entered the last war, work was started on a self-propelled mount for heavy guns. In 1918 the Christie motor carriage for the eight-inch howitzer was produced, many Holt caterpillar tractor parts being used in its construction. It weighed 17 tons, and a 120-horsepower gasoline engine gave it a top speed of 16 miles per hour. It had rubber-tired wheels, the center ones independently sprung, and removable caterpillar tracks. Tests proved that it could be maneuvered easily over difficult ground, and 300 mounts, to be delivered early in 1919, were ordered—250 for the 240-mm. howitzer, 50 for the eight-inch howitzer, and 50 for the 155-mm. gun. When the war ended, all the orders were curtailed and only a few experimental models were built.

During the course of World War I the French did considerable development work on track-laying artillery carriages, and finally produced the St. Chamond mount for heavy howitzers. This carriage was built in two units. One of them carried the howitzer. The other, a limber, carried the gasoline-engine power plant and ammunition. The limber could be driven into cover while the gun was in action. The St. Chamond didn't get far beyond the experimental stage. The British built 50 tanks designed to carry six-inch howitzers which could be fired from the tank or, with more accuracy, from the ground. They were not successful. The British did not build any real self-propelled guns. There is no record of the Germans having even experimented with self-propelled artillery.

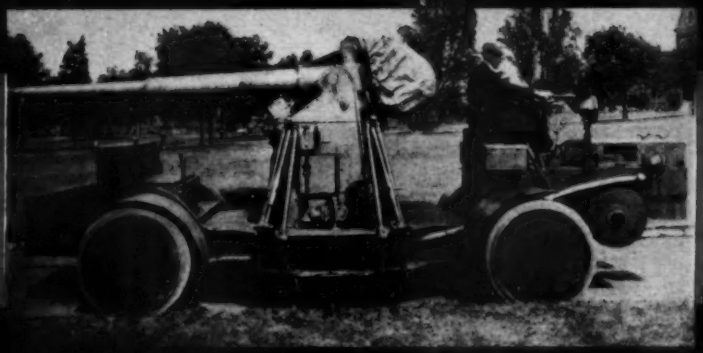
After the war, our automotive-minded Ordnance officers continued their efforts to produce satisfactory self-propelled gun mounts under the direction of Col. Lucien B. Moody. Among the workers were Maj. Gen. Levin H. Campbell, Jr., the present Chief of Ordnance, and Brig. Gen. Gladeon M. Barnes, now in charge of ordnance development, who then were captains, and Cols. B. C. Lewis, W. A. Capron, and H. W. Alden. Among the civilian engineers who did valuable work were Carl Bock, now chief engineer of the General Motors Truck Company, and W. F. Beasley and D. A. Gourney, both still *(Continued on page 207)*

75-MM. GUN MOTOR CARRIAGE, M-3

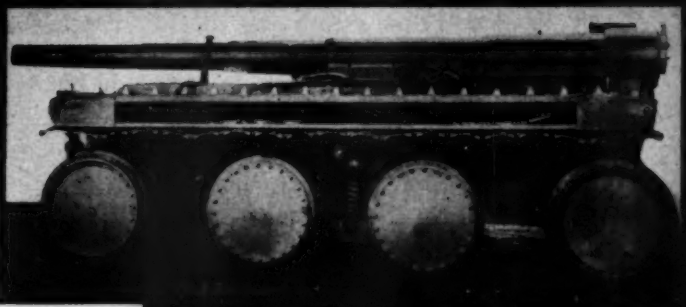
Here is the famous half-track. It can be used for either direct or indirect firing and carries armor-piercing and high-explosive shells. Below, the loader is ready to ram a shell home; right, he takes a shell out of its storage compartment

From the Album of American Self-Propelled Guns

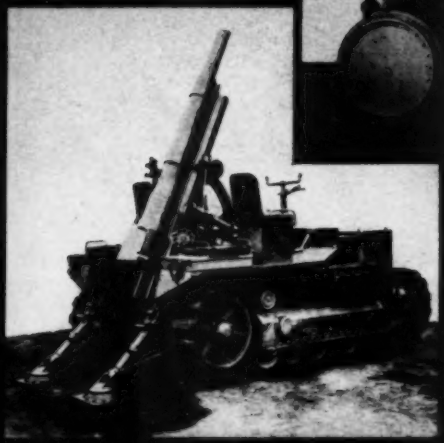
Courtesy Maj. R. O. VanNess & W. P. Seese



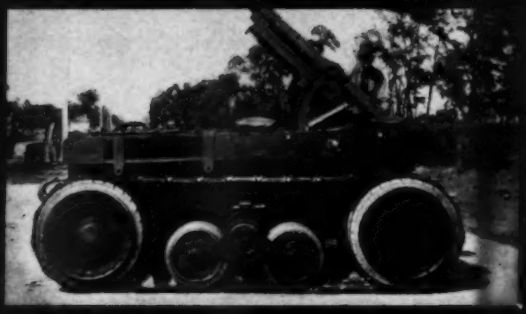
This was the first really self-propelled gun. The carriage was built in 1917 by Christie, a veteran race driver, who is at the wheel in this picture



One of four Christie carriages built in 1920 for 155-mm. guns. They weighed 20 tons and made 11½ miles per hour. Front and rear wheels were rigid and the center ones sprung



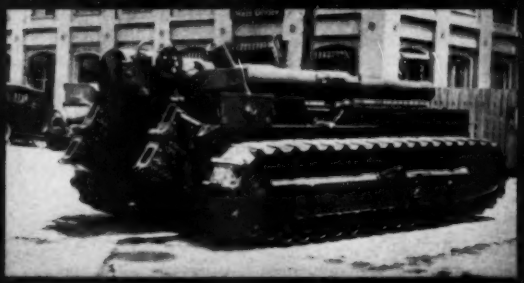
Also built about 1920 was this 5¼-ton caterpillar tractor mounting a 105-mm. howitzer. Carriages similar to this did 30 miles per hour, which was considered excessive, and the speed was reduced

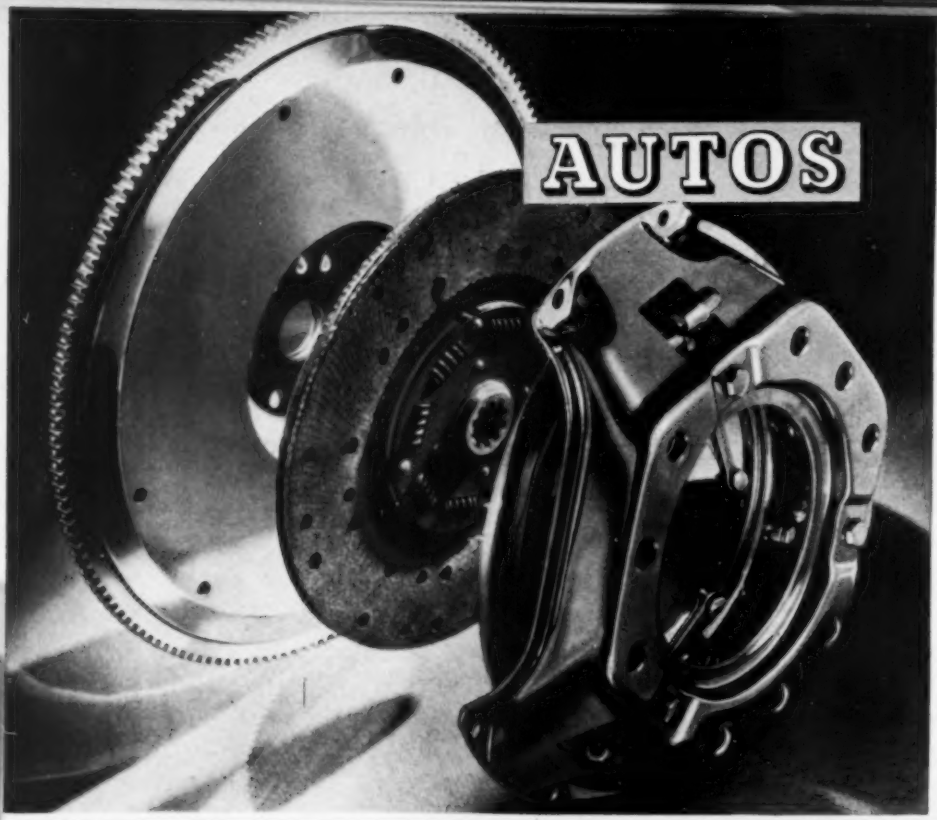


In 1921 two of these carriages were built for our 75-mm. gun and 105-mm. howitzer. They had both tires and tracks

At left is an early 75-mm. tractor gun taking a ditch. Forward-pointing guns were a big advance since they could be fired as soon as they halted

The big motor carriage mounting the 155-mm. gun below was a 1921 model. A similar one carried an eight-inch howitzer





What To Do About

By RALPH ROGERS

MOST common of clutch troubles is the "slipping" clutch. This may be due to any of several things, including a worn facing on the driven plate, improper installation of the clutch facings, oil-soaked, torn, or improper type of lining, weakened or broken clutch pressure springs, worn splines on the clutch gear, a clutch lever that is improperly adjusted, and an incorrect assembly of the clutch cover parts.

However, the most common reason is that the clutch pedal has little or no free play. In other words, there is not enough free travel in the pedal before the clutch actually goes to work. An explanation of how a clutch works will reveal both the cause and the cure of this trouble. Reference to the diagram on the facing page will help in following the text.

For the past five or six years, most clutches built have been of the single-plate, dry-disk type, all operating on the same principle. The Hudson clutch is also a single-plate unit that operates in a special oil, but instead of the conventional clutch facings, the clutch plate is provided with many flat, round, cork disks.

When a clutch is engaged, that is, when the facings are held firmly between the surfaces of the flywheel and the pressure plate, all the power delivered by the engine is transmitted from the clutch plate to the transmission and thence through the drive shaft and rear axle to the wheels. When the clutch is disengaged by stepping on the pedal, the pressure of the release bearing compresses the clutch springs, causing the driven plate to free itself from the pressure plate and flywheel, and thus disconnecting the engine from the transmission.

As the clutch facings wear, the pressure plate moves closer to the flywheel face and the release levers connecting the foot pedal with the release bearing move toward the transmission. This causes the inner ends of the levers to travel farther toward the

transmission, which decreases the clearance between the release levers and the release bearing. As a result, the free travel of the clutch pedal is shortened, until it rides the toe board. The clutch then slips constantly.

The clearance between the toe board and the point where the release bearing contacts the release levers should be maintained as specified by the car manufacturer.

When a clutch grabs or chatters while engaged, it may be because of gummy linings torn loose from the driven plate, loose engine mountings, a scored, cracked, or broken pressure plate, improper adjustment of the clutch levers, flattened-out clutch-plate cushion springs, worn clutch gear splines, or a clutch cover assembly that is not tightened to the flywheel.

A clutch that drags when disengaged may have too much pedal free play. Improper adjustment of the clutch levers, a warped pressure plate or driven plate, torn clutch facings, distorted, burred, or rough clutch shaft splines, and a driven-plate hub that is too tight on the clutch shaft are other faults that may cause dragging.

If the clutch is noisy when disengaged, the clutch release bearing may be damaged, dirty, worn or improperly lubricated, or it may be binding in the release shaft arms. The clutch pilot bearing may be defective or not properly lubricated. Clutch levers improperly adjusted and rubbing against the driven-plate hub may also cause this noise.

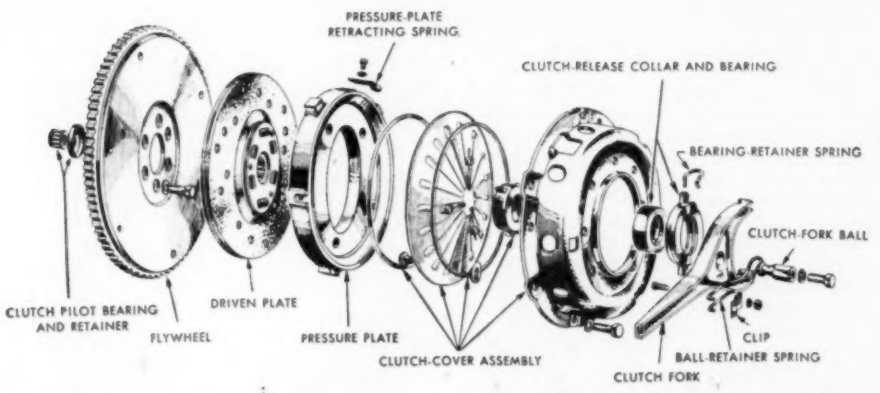
If the noise occurs when the clutch is engaged, it may be caused by improper alignment of the transmission with the engine. This noise is usually noticeable at low or idling speeds. A loose hub on the driven-plate connection to the shaft splines may be the reason, or the hub bolts on the driven plate may be loose, or the driven-plate damper springs weak or broken.

Clutch trouble on the Hudson can usually be traced to the condition of the corks, which may become glazed because the wrong type fluid is being used. In that case, the clutch should be flushed with kerosene and refilled with the proper lubricant.

Except on torque-tube drive jobs such as the Buick, Ford, and Chevrolet, the clutch can be removed easily by disconnecting the propeller shaft and then removing the transmission. Take off the clutch housing pan, *but before removing the bolts which fasten the clutch assembly to the flywheel, make a punch mark on both the flywheel and clutch cover so that when the clutch is reinstalled, the original balance will be maintained.*

If replacing only the driven plate, do not disturb the adjustment of the release levers,

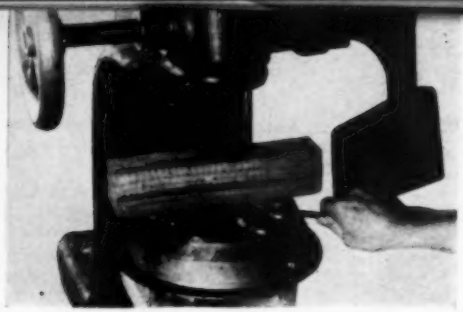
Clutch Trouble



Exploded view of a diaphragm-spring type clutch. The dished or cone-shaped diaphragm spring that is shown here as part of the clutch cover assembly serves the same purpose coil pressure springs do in more conventional types of automobile clutches

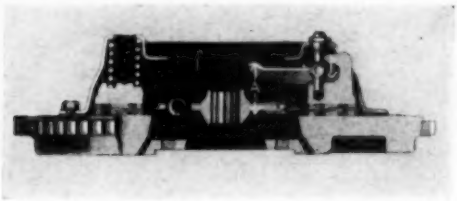
With the clutch pedal out, the flywheel is directly coupled with the transmission. However, when the clutch is disengaged, the driven plate is relieved of the pressure of the diaphragm spring. The drive faces may then draw apart, and transmit no power

Above, the parts of a coil pressure-spring clutch in correct position for assembly. The cover is pressed down, compressing the springs within, and the nuts are then threaded on and tightened. After assembly, release levers are adjusted as at right



In taking apart the coil pressure-spring clutch, force cover down to remove nuts. Then ease it up slowly so the springs inside will not fly out

Release levers must be adjusted at point A in accordance with manufacturer's specifications



because upon their proper adjustment depends the efficient operation of the clutch. If, however, the clutch cover assembly is to be dismantled, and the same cover and pressure plate are to be used again, *be sure to punch-mark both of these parts so that assembly may be made correctly.*

In dismantling the clutch cover assembly, the usual practice—unless a special clutch fixture is available—is to mount it on the bed of a press with a wooden block under the pressure plate, so arranged that the cover is free to move down. Then compress the cover with the spindle of the press, using another wooden block on top of the cover. With the cover held under compression, remove the adjusting nuts; then slowly release the pressure to prevent the springs from flying out. The cover can then be lifted off, revealing all the parts. Before completing the dismantling operation, make careful note of the position of all parts.

When the pressure springs show signs of overheating due to clutch slippage, they should be replaced. Overheated springs will show a pronounced blue color, indicating that the temper has been drawn.

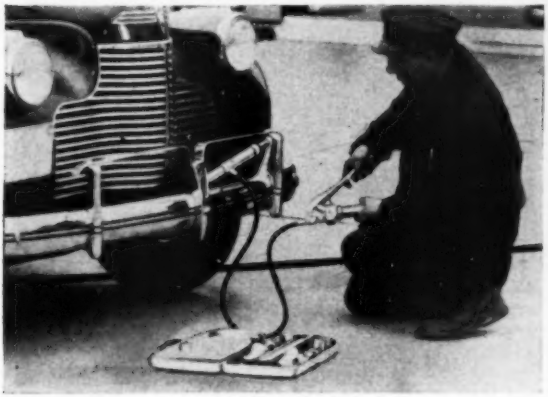
Examine the pressure plate. If its surface is marred, scored or heat-checked, it should be replaced. Grinding a pressure plate is seldom satisfactory as proper clearances cannot be maintained. Satisfactory operation depends absolutely upon the accuracy of the lever adjustment, for the pressure plate must be parallel with the flywheel.

Just what method is to be used to check the position of the levers depends upon the equipment available. Regardless of how the clearances are measured, they must be uniform to .005" so that they will all contact the release bearing simultaneously. If a clutch fixture or a proper gauge is not available, take the clutch to a clutch-rebuilding establishment for adjustment.

Lack of free play in the pedal resulted in bad scoring of this pressure plate. A simple adjustment would have saved the car owner a repair bill

AUTO Ideas

THIS MIDGET HYDRAULIC UNIT will repair and straighten out almost any portion of a damaged car body. It may be carried complete with its attachment in a small metal case. The pump weighs 4½ lb.



LICENSE PLATES for 1943 in many states consist of tabs mounted on the 1942 plates. The tab shown above is made of a light laminated plastic prepared from a phenolic compound. Printed sheets bearing the required design are placed on resin-impregnated sheets of paper, and under a temperature of 250 deg. and 1,500 lb. pressure are bonded together.

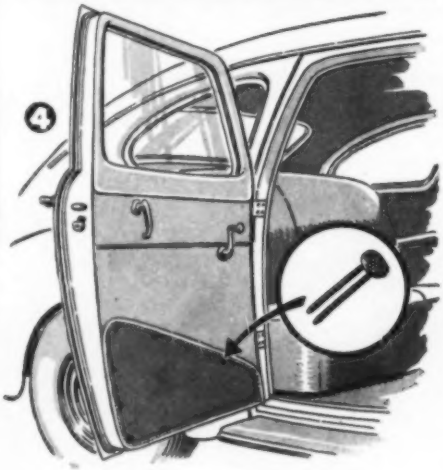
REMOVING HORSESHOE WASHERS from around the anchor pins of brake-shoe assemblies is easy with the tool below. A few taps at the square end cause the points at the other end to spread apart, forcing the anchor washer to open. The tool removes any size washer without damage, and the part may be used again.

PLASTIC FITTINGS can be used with ordinary metal tubing in making repairs on gas lines and the like. These fittings have been shown to be practical for use on oil, gas, water, and air lines operating within certain temperature ranges. Plastic tubing as well as the fittings can be had in a complete range of sizes for automobile use.

OLD SPARK PLUGS are a recognized source of easily salvaged strategic metals, and under WPB regulations, motorists now must turn in worn-out plugs when purchasing new ones. In one test salvage drive, 7,400 old spark plugs yielded a total of 882 lb. steel, 39 lb. copper, 25 lb. nickel alloy, and 54 lb. brass. Nothing but a hammer is needed to break plugs up so that the different kinds of scrap can be separated. Supply officers are pleased with the quantity of high-grade scrap salvaged in this way.

USEFUL AUTO HINTS

DRAWINGS BY STEWART ROUSE



1 **CAR KEYS** can be easily identified by drops of solder. For instance, the gas key might have one drop of solder, the ignition key two drops, the door key three drops, and so on. Tin the surface first to make the drops adhere. With this system, keys are easy to distinguish from one another even in the dark.—W. K. K.

2 **AUTOMOBILE STICKERS,** inspection tags, stamps, and the like should be placed on the windshield in such a position that they will not conceal other cars or pedestrians. If they are placed near the center at the very bottom of the windshield, in line with the hood of the car, they will in no way obstruct the driver's view, and may still be seen clearly from outside.—G. J. K.

3 **AN INGENIOUS HOLDER** for hanging clothes in a car can be improvised on short notice. Take a piece of rope about 6″ long, double it, and tie the two ends together. Place the knotted end outside the window. When the window is closed on the rope, the part hanging on the inside forms an adequate loop for a hanger.—T. D.

4 **SCUFF PADS** placed as shown in the drawing will protect your car's upholstery. The pads are made of artificial leather or other durable material. Cut them to fit the door, bind the edges with tape, and fasten with ordinary upholstery pins. The material used for this may be matched with the upholstery fabric on the door panels of the car.—J. B.

"They tell me you're a genius," said the man at the shop door

Gus Tackles a Job for a Genius

THE MODEL GARAGE EXPERT SOLVES A PROBLEM THAT HAS EVERYBODY GUESSING

By MARTIN BUNN

"MISTER," said a voice at the open shop door, "I hear you're a genius. Well, I've got a job for a genius."

Gus Wilson looked up and saw a fat man standing there smiling as he mopped his perspiring red face with an oversize handkerchief. Gus grinned back at him. "It's a bad habit to believe everything you hear," he observed. "Come in, won't you?"

The fat man came into the shop, stripped off his coat, and settled himself comfortably in the only chair. "My name's Warren," he announced. "I work in the Johnston and Fredericks plant."

"Oh, so you're *the* Mr. Warren, are you?" Gus said. "Mr. Johnston has been telling me about those special machines you've designed for him. Well, if there's a genius in this shop just now, you're it, Mr. Warren."

Warren waved a disclaiming hand. "I'm no genius—far from it," he said. "Except for machine tools I'm just a dumb cluck, or, as my young daughter might put it, a drip."

"Well," Gus told him, "you have it your way, and I'll have it mine. But what's this job you were speaking of?"

"It's precisely what I said it was—a job for a genius," Warren insisted. "I told Mr. Johnston about the troubles I am having with my car. 'Take it to Gus Wilson at the Model Garage,' he advised me. 'He's a genius at trouble-shooting.' Well, I'm here, and the car is just outside your door."

"Fine," Gus said. "But what's the matter with it?"

"That's what I don't know, and what no automobile mechanic who has looked at it—and I've taken it to a lot of them during the past two months—has been able to find out," Warren told him. "I do know that the engine stalls frequently, but I don't know why it stalls. Sometimes it will run perfectly for days and even weeks, and then without the slightest warning it suddenly stops and refuses to restart. Other times it will stall half a dozen times in a single day.

"Usually, if I let it stand for an hour or so, it will restart without any trouble and run as smoothly as a man could ask. But on several occasions I've had to have it towed to a garage—and then suffer the embarrassment of having it take off the instant some supercilious mechanic stepped on the starter. Because no one has been able to find out what makes it behave as

GUS SAYS:

Before summer gets too much of a head start on you, better get the dust out of your air cleaner. You know, it's often little things that cause a heap of trouble—and that's as true of a car as it is of life. If you haven't changed your oil by this time, better not put that off any longer!

it does, no work has been done on it. The entire matter is a confounded mystery that I'm delighted to turn over to you."

Warren beamed at Gus, settled himself even more comfortably, and began to cram tobacco into the bowl of a large pipe.

"Well, I'll bring your car in and do some checking," Gus told him.

"I'll be highly interested in watching you," Warren approved. "I always enjoy seeing a topnotcher at work."

Gus went out and got into the '42-model coupe of a popular make that was standing at the door. Switching on the ignition, he pressed his foot on the starter. The engine at once purred smoothly. He drove into the shop and got out. With Warren eyeing his every move, he checked the ignition and the fuel line. Then he went over the engine carefully. Everything seemed to be in perfect condition. Puzzled, he shook his head.

"Stumped?" Warren asked.

"Stumped," Gus admitted. "So far as I can see, your car is in perfect mechanical condition. To find the cause of the stalling, I'll have to check the engine *after* it has stalled. Let's leave it this way, Mr. Warren. The next time you have trouble, don't do anything about it except phone me right away." Gus jotted two telephone numbers on a card. "Top number in daytime, bottom one at night. I'll tow your car over here from wherever it is and check it thoroughly. That way I'll be able to find out what's wrong without wasting time guessing."

"I'll do that," Warren agreed.

It was less than a week later that Gus's bedside telephone jangled once, twice, three times in the darkness. Finally its disturbance hammered through sleep into his consciousness. He rolled over, propped himself up on one elbow, switched on the light, saw by his alarm clock that it was three o'clock, and finally picked up the receiver.

A voice at the other end of the wire said: "This is Warren. You told me to call you the next time I had trouble with my car. Well, I'm having it. The engine wouldn't start when I wanted to go home. . . . What? . . . It's right in front of the plant. . . . No, I haven't done a thing to it. . . . You'll be over in half an hour? Good. I'll leave the car keys with the guard at the gate—I'm going home in a taxi and to bed. Your baby now, Mr. Wilson! Give me a call when you've got it fixed, will you?"

Gus yawned and stretched, got into some clothes, went downstairs and climbed into his car, and drove the few blocks to the Model Garage. There he took out the wrecker. He drove to the Johnston and Fredericks plant, which was running full blast. Warren's coupe was standing at the curb in front of the office gate. As he got out of the wrecker, a uniformed guard came over to him and said, "You Mr. Wilson?" Gus grunted in answer, and the guard handed him a couple of keys.

The first thing Gus did was to turn on the ignition and step on the starter. The starting motor whirred, but nothing else happened. He got out of the car and, using his flashlight, made sure that the gasoline-tank vent wasn't clogged up and that there was plenty of gas in the tank. Then he checked the spark plugs. They were delivering good, hot sparks.

Next, he had a look at the carburetor—and found that there was no gas in its bowl.

"Well, I still don't know what the trouble is," he told himself, "but at least I know that it's in the fuel system somewhere between the gas tank and the carburetor. That's something gained."

He towed Warren's car through the deserted streets to the Model Garage and maneuvered it into his shop. On an impulse he couldn't have explained, he turned the engine over with the starter a few times, the ignition off. Then he looked at the carburetor again and got a surprise.

There hadn't been any gasoline in its bowl when he had examined it in the street in front of the Johnston and Fredericks plant, but there was plenty of it now.

Gus scratched his ear thoughtfully for at least two minutes before he made his next move. That was to get into the car and step on the starter, with the ignition on this time.

The engine took off promptly!

"Right back where I started from!" he growled disgustedly. "No—not quite that bad; I know where the trouble *was*. Well, now, let's see. That carburetor is O.K. now, but it wasn't O.K. when I checked it twenty minutes ago, so in all probability it wasn't working right when Warren couldn't start his engine a half hour before that."

He examined the carburetor again, but still couldn't find anything wrong with it. Then he removed it from the car, carried it over to his workbench, took it apart, carefully examined and cleaned each of its parts, reassembled them, and replaced the carburetor on the car. "Nothing wrong with it now, I'll swear," he assured himself.

Next, he checked the fuel pump. It was working perfectly. Inch by inch he went over the fuel line from the gasoline tank to the carburetor. It was tight and clean.

He got back into the car and stepped on the starter. Again the starting motor turned over without as much as a sputter from the engine.

Examination showed that once again there was no gasoline in the bowl of the carburetor.

"Whatever it is," Gus muttered, "it must be in the fuel tank—it can't be anywhere else. I'll have to take the tank off."

He started to do this by disconnecting the fuel line from the tank, keeping a can handy to catch the gasoline which he expected to gush out of the opening the moment the line was detached. But only a few drops dribbled out.

Gus turned his flashlight so that it shone into the opening. In its white beam something brown appeared. He poked at it with his finger tip. It moved — and gasoline spurted out as he had expected it would.

He drained the tank. Then, with a piece of fine wire one end of which he twisted into a hook, he began to fish. Before long he felt the hooked wire catch something soft. Manipulating it carefully, he worked out a piece of wrapping paper about the size of a business card.

About noon, Warren came into the shop, smiling broadly. "I got your phone message," he said. "So you lived up to your reputation! Well, what caused all my troubles?"

Gus handed him the bit of wrapping paper. "That did," he said. "Somehow it got into your gas tank. Whenever it floated over the outlet where the fuel line is connected, it cut off the flow of gas to the carburetor, and of course your engine couldn't run. When it floated away from the outlet, the flow of gas was unimpeded, and the engine could run."

"Simple, wasn't it?" Warren said. "But locating the cause of the trouble wasn't simple. You see, it was just what I said it was in the first place—a job for a genius. Don't forget that when you bill me, Mr. Wilson!"

It was 3:30 A. M. when Gus began hunting the trouble with a flashlight

Home Dehydrator

Easily built drying unit will help to preserve the bounty of your Victory garden for year-round enjoyment of its vitamins, minerals, and flavor

How to Dry Foods at Home to Boost Your Wartime Rations

ALONG with millions of other patriotic Americans, you probably have a Victory garden well under way and soon will begin gathering crops. Like them, too, you probably will have far more of some kinds than you need to supply your family table. Part of this surplus you will want to can, pickle, and make into preserves, jams, and jellies; some items you may wish to store in the cellar or in outdoor pits. This year it is a good idea to dehydrate some of the foods.

Dehydrated foods keep well and take little storage space, 1 lb. equaling 3 to 12 lb. of the fresh product. Their vitamin value is attested by the fact that the Army is purchasing many dried items. For home drying, the U. S. Department of Agriculture recommends both fruits and fresh vegetables. The fruits include apples, apricots, figs, peaches, pears, blackberries, dewberries, loganberries, raspberries, cherries, and plums; the vegetables, sweet corn, shelled mature beans and peas, beets, snap beans, peppers, pumpkins, squash, and leafy vegetables.

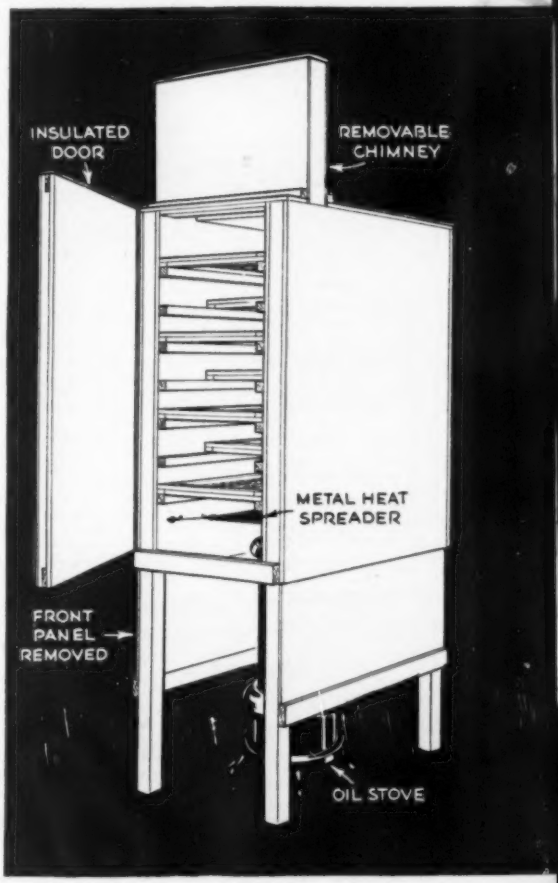
Home drying with artificial heat can be done in a cabinet having removable trays on which the foods are placed. Hot air rises through the cabinet from a heater underneath it and is baffled around and over the trays. These are 5″ shorter than the depth of the cabinet and are placed alternately against the back and front.

To construct the cabinet, make two side frames of 2″ by 2″ stock as shown in the drawings. The upper 38″ section of each frame is covered with ½″ stock on the outside and with ½″ insulation board in one piece on the inside. Slides for the trays are nailed across the inside of each face from the front edge to within ½″ of the rear edge, leaving space for a sheet of ½″ insulation board inside the back.

This sheet of insulation, measuring 15″ by 38″, is tacked to the ends of the tray slides to begin the assembly, after which the toppiece and cross brace are attached to the front posts, and boards are fastened on for the back. Attach the top next, putting a 3″ board at the front end, leaving a 3″ space behind it, and then adding the wider boards. Top insulation is put on in two sections nailed from the inside.

A removable plywood chimney fits into the vent, a 1″ by 1″ strip across front and back holding it in place. Nails driven partly through the strips help to keep it rigid. They can be withdrawn for removing the chimney when the cabinet is to be stored.

The seven trays are all alike, measuring 14½″ by 23″. They are made of ⅛″ or ¼″ galvanized wire mesh framed on both sides by ½″ by 1″ wood strips, but wooden slats will serve. The door is constructed of 1″ by 2″ stiles and rails, jointed as shown, then



completely covered on the outside with ¼" plywood or other stock and on the inside with ½" insulation board.

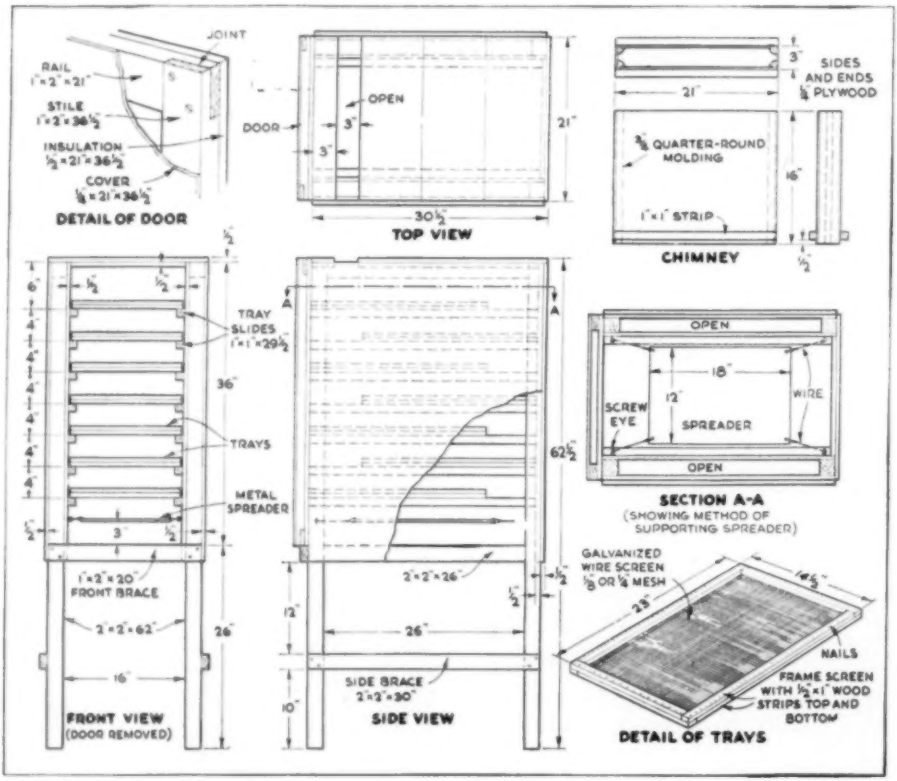
Fireproof aprons of asbestos sheets or sheet metal are nailed permanently to the sides and temporarily to the front and back, to protect the stove from drafts and to direct the heat upward. A piece of sheet metal suspended by wires from the four corner posts spreads the heat. The distance between the top of the stove and the spreader should be at least 2".

A medium-size kerosene stove will supply sufficient heat, which should vary from 125 deg. F. to 160 deg. F. during the drying period of foods. Other types of controlled heat, including gas and electric heaters and even a battery of light bulbs, may be used instead. An electric fan may be included to circulate the heat more rapidly. A thermometer should be used to check temperatures.

The cabinet is heated before the filled trays are put in, and in general the heat is increased during the middle stages of drying. The drying foods should be moist to the touch and cooler than the air flowing over them. If they feel hot and dry, the drying is too rapid. The time required will vary according to the kind of food, the size of the pieces, the type of drier, and even the weather. Fruits may take from 6 to 24 hours, and vegetables from 3 to 15 hours.

The positions of the trays are changed every 30 minutes or so during the drying period. Remove the top tray and place it at the bottom, raising each tray up one place at each change. Be sure to alternate the trays against the back and front every time they are changed so the hot air will travel back and forth between them.

Fruits are ready to be removed from the drier when they are leathery and tough, and vegetables after they have been dried to brittleness. If in doubt, heat them a little longer at a reduced temperature. Some pieces may not be completely dried when the batch is removed. Cull these, as they may mold during storage. If there is a period of time between drying and storing, reheat the foods to 165 deg. just before storing. If during storage there is any sign of moisture upon occasional inspection, reheat the foods and repack them.



The various kinds of fruits and vegetables require different methods of preparation prior to being dried. Some are steamed, others boiled, and certain fruits are treated with sulphur. One level teaspoon of sulphur is used for each pound of prepared fruit. Wrap the sulphur in paper and place it in a shallow tin pan about 7" below the bottom tray. Light the paper, which will ignite the sulphur and release fumes to rise through the cabinet. *Be sure to do this outdoors* so that the fumes will escape harmlessly into the open air. While apples, peaches, and apricots are usually sulphurized before drying, they can also be dried after steaming.

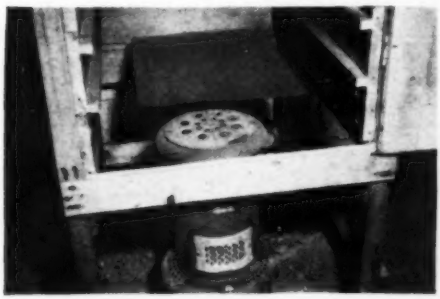
Vegetables should be cooked in steam or boiling water before dehydrating. Steaming is said to preserve higher food values. If vegetables are boiled, only small amounts should be prepared at a time. To conserve vitamins and minerals, use the same water for several lots of the same kind of vegetables and cook as fast as possible to a point where they are almost tender.

Fruits should be mature, but not soft, and in prime condition. Apples are washed, pared, cored, and sliced. Peaches are peeled by dipping into boiling water, then halved or quartered, and dried with the pit side up. Apricots are dried with the skin on. Berries should be picked in early morning and dried quickly. They are spread two layers deep with a piece of cloth over the trays to keep them from sticking. Cherries are pitted and drained for about an hour; then they are spread in a single layer on the trays. Pears are sliced or cut into quarters or eighths. If the pieces are not dried immediately after preparing, keep them in a solution of four teaspoons of salt to a gallon of water.

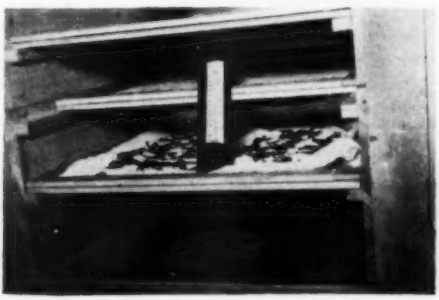
Dehydrated foods should be packed in air-tight containers, such as coffee cans with the tops sealed with tape, tightly sealed glass jars, or friction-top cans, and stored in a dry place.

The amount of elapsed time between picking fruits and vegetables and putting them into the dehydrator to dry is important. The shorter the time consumed the better, because the vitamin value, flavor, and cooking quality will be higher.

When preparing the foods for table use, soak them from ½ to 6 hours, adding as much water as necessary, and cook them in



Heat from an ordinary oil stove is sufficient to dehydrate fresh fruits and vegetables. A metal spreader will prevent scorching of the lower tray



Fairly constant temperatures must be maintained. Check them with a thermometer kept on the bottom tray. Staggering the trays aids the hot-air flow

Sulphurizing before drying is advisable for some fruits. The sulphur may be burned in a small tin

Peaches are halved or quartered for dehydrating; beans are sectioned and laid on a piece of cloth

the same water. Dried greens do not require any soaking. Cook these in salted water until they are tender.

Almost every fruit and vegetable calls for a different method of preparation as well as different drying time and temperature. The Department of Agriculture offers at a nominal cost (5 cents) Farmers' Bulletin No. 984, Farm and Home Drying of Fruits and Vegetables, giving comprehensive directions for home drying. With this bulletin and the dehydrator described, you can preserve the produce from your Victory garden, as well as fruits bought in season, for use when fresh foods are not available or are too expensive for the family budget.

Table-Model Drier Used in Kitchen

HERE is a table-model home dehydrator developed by the Tennessee Valley Authority and the University of Tennessee. It gets its heat from a battery of electric-light bulbs, and circulation is hastened with an ordinary electric fan. Both can be plugged into household wall sockets.

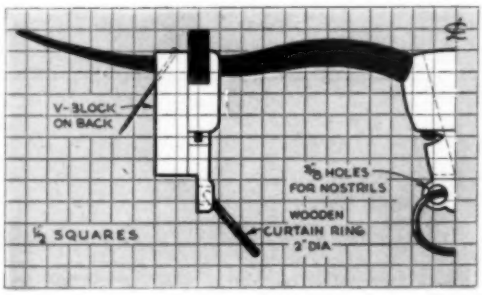
The unit will handle a half bushel of fresh fruits and vegetables at a time on trays approximately 18" by 18". Materials used in construction are inexpensive.

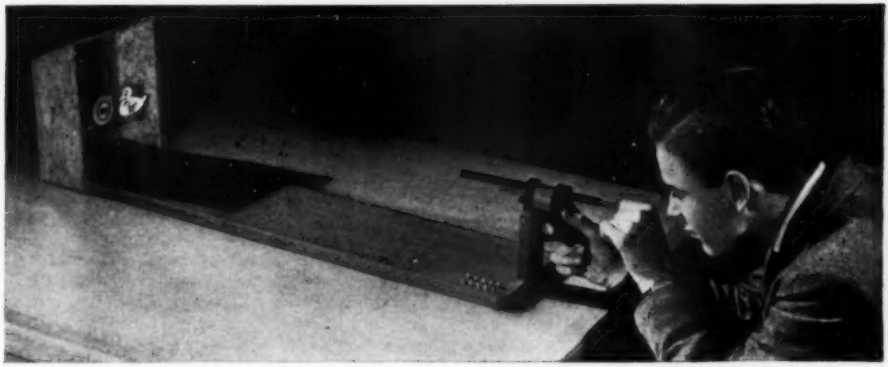
Longhorn Rack Holds Many Ties

LONGHORN cattle are almost a thing of the past, but this wooden replica of a steer's head forms a unique tie rack. It should be made of straight-grained, dry softwood. The horns are bandsawed in one piece, from a 20½" length of ½" by 1" stock. Round the edges and screw and glue the horns to the back of the head.

A piece of ¾" by 2½" by 3¾" stock is used for the head. Bore the holes for the nostrils; then shape the piece as shown. Insert wood beads or glass marbles for eyes. Cut out a section of a curtain ring as wide as the nose between the nostrils, notch the outer edges of the nostrils to let the ring hang straight down, and glue it in.

A V-shaped block of wood screwed to the back of the head, with two holes drilled down through the top edge on a slant, will provide a suitable method of fastening the rack a little distance away from the wall. Paint the head brown, the forehead cream, and the eyes black. Finish the horns with orange shellac.—H. P. DONER.





SAFE AND SANE SHOOTING GALLERY IS A SURE-FIRE HIT

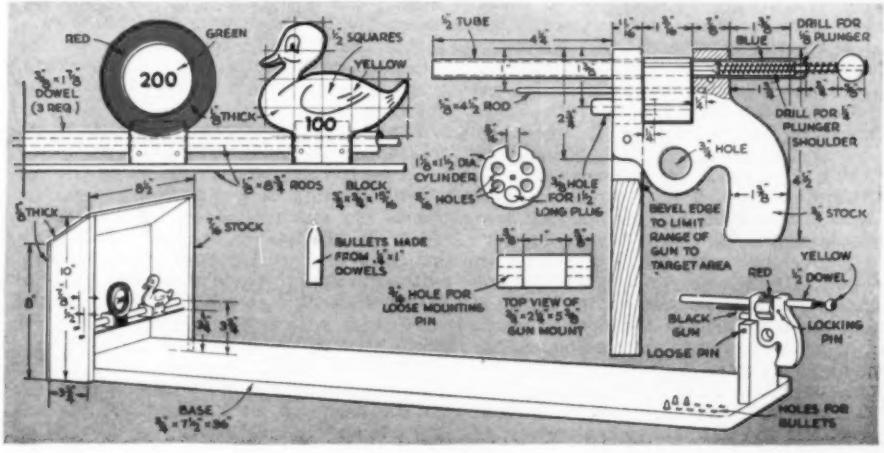
By Myron Fleishman

A ROOTIN', tootin', shootin' gallery that you can easily build at home will afford your family hours of enjoyment and be great fun at parties. The gun is mounted so that it cannot be aimed sideways or up in the air, thus restricting all shots to the gallery itself and making the game safe for children.

The base is a pine board ¾" by 7½" by 36". At one end is the gun mount and at the other is a backstop constructed of 7/16" stock. Both the targets are cut from heavy pressed board, and after being painted and labeled with the scoring number, they are nailed to wooden blocks and mounted so as to pivot on a wooden dowel in the gallery. They rest at the front on a second dowel or a piece of heavy wire placed as shown in the drawing. When hit, they fall over backward.

The gun is fashioned from ¾" stock, and the barrel formed of a cardboard tube or a thin tube of sheet metal. Two springs are used in the plunger which releases the shot —a strong firing spring and a weak recoil spring, the latter holding the plunger back so that bullets may be inserted. Any number of bullets can be made from short pieces of dowel. Point them at one end with a knife or in a pencil sharpener and fit them into holes drilled in the base.

Both the base and gallery should be stained and varnished. The gun and targets may be painted as shown in the drawing.



Bat raised, kangaroo in position, the player on the right aims for the "hole" while her opponent watches

KANGAROO GOLF

By PATTY DE ROULF

KANGAROO GOLF is a new and fascinating game the whole family can play out in the back yard, at the beach, or on a picnic. Although it has been patented by the inventor, Pietro A. Yon, the readers of POPULAR SCIENCE MONTHLY are invited to make their own equipment from the drawings accompanying this article.

The "kangaroos" are little wooden sticks that fly through the air when they are struck from a wooden tee with the narrow side of an oval-shaped bat. Mr. Yon, world-famous organist and composer, and musical director for St. Patrick's Cathedral in New York, received the inspiration for the game when he watched a group of boys playing "old cat" in a village near his home in the Alps.

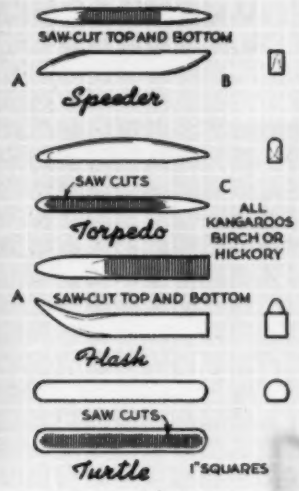
Collapsible wooden enclosures are used in place of the usual golf holes. A kangaroo is placed on a tee so that it extends from 1" to 2½" over one edge. When it is hit with the bat, it will soar through the air for distances up to 50 yds. The game is scored similarly to golf, the smallest number of strokes around a nine-hole course winning the game.

The course can be laid out over any kind of terrain, and obstacles such as hedges, bushes, and the like add to the interest of the game. The enclosures, or holes, should be not less than 25 yds. nor more than 50 yds. apart. A good score for such a course is about 25 strokes. Each player has a set of four kangaroos, a tee block, and a bat, all of these being carried in a sack slung over the shoulder.

Direction of the kangaroos can be controlled by the tee as well as by the shape of the kangaroo itself. For example, if it is desired to have the kangaroo jump high, the tee should be placed with its highest edge facing the hole. If you want to hit the kangaroo level with the ground or downhill, place the tee with the low edge facing the hole.

Each one of the four kangaroos in the set is shaped differently. The Speeder is used for velocity and height. Strike end *A* for a low, fast flight, and end *B* for a high, fast flight. To attain distance, the Torpedo is used. If the player strikes end *C*, this kangaroo will usually stop where it lands without rolling. When it is necessary to go from low to high ground, use the Flash, striking it with end *A* pointed up; to get from high to low ground, strike this kangaroo with end *A* pointed down. Added distance can be gained by using Turtle, the fourth kangaroo, as it is designed to roll when it strikes the ground.

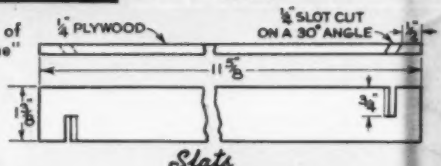
Pietro Yon, at left above, world-famous organist and inventor of Kangaroo Golf, looks on while two friends try for a "hole in one"

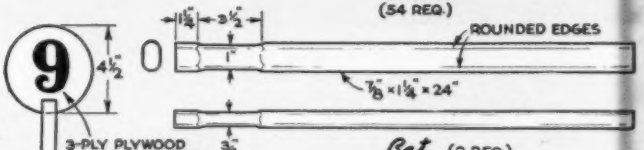


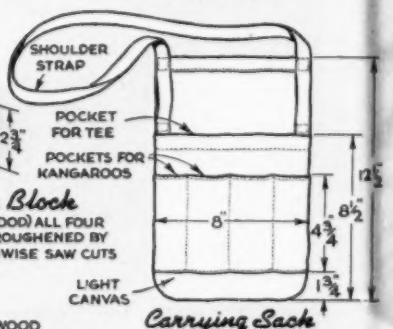
EASY TO BUILD AND FUN TO PLAY

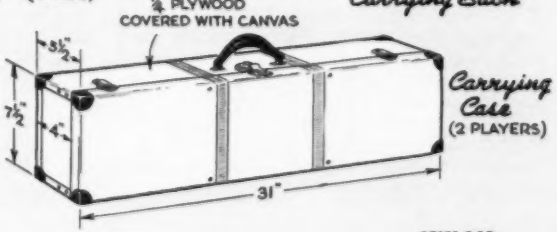
RULES

1. One or more persons may play either for individual scores or as partners.
2. Each player has four kangaroos, any one of which may be used.
3. The starting point from each marker should not exceed the length of the bat.
4. Each player hits a first stroke. The second stroke is made by the player whose kangaroo is farthest from the hole. Others then play second strokes and continue in this manner until all have completed the hole.
5. After every stroke, the player places his tee block so as to touch the kangaroo wherever it has landed. In difficult positions, the tee may be placed at a distance of a hand span from the kangaroo, but not in the direction of the hole.
6. After striking the kangaroo, the player may strike it again while it is in flight without a penalty.
7. If the kangaroo breaks, or becomes damaged, the player may replay the hole.
8. The first stroke may be repeated if desired without a penalty.
9. If the kangaroo is lost, the hole must be replayed.
10. Penalties (one count): When a player misses the kangaroo in striking; when the kangaroo lands in a tree or other obstacle necessitating employment of other methods to recover it, or when it is lost; when the kangaroo is moved sideways, or backwards away from the hole, for a distance of not more than twice the length of the bat.
11. Additional rules may be made according to special conditions.





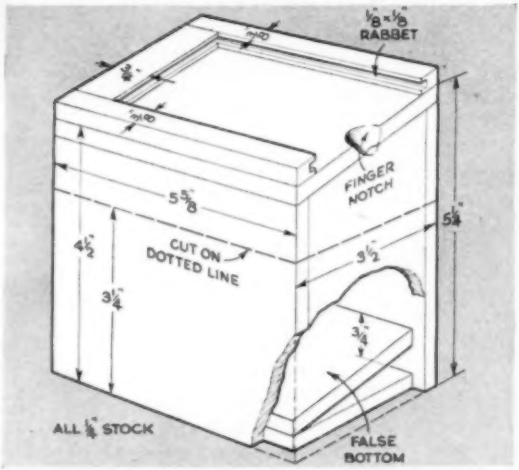




Recipe Box Holds Card Under Glass for Ready Reference in Cooking

Build a closed box with a top and bottom; then cut it apart carefully as shown above

Any card inserted under the glass is completely protected



LIST OF MATERIALS

No. Pc.	Description	T.	W.	L.
1	Front	¼	4¼	5⅝
1	Back	¼	5	5⅝
2	Sides	¼	3	5
1	Top	¼	3 9/16	5⅝
1	Bottom	¼	3	5⅛
1	False bottom	¼	3 1/16	5⅛
2	Top slides	¼	⅝	5⅝
1	Top slide	¼	¾	3¼
1	Glass cut to fit slide			
1	Pair small box hinges			

Note: All dimensions are given in inches.

A NOVEL recipe box designed to hold about 250 standard 3" by 5" filing cards has a glass top under which the card to be used is inserted. In this way the written matter is kept clean and in good condition at all times.

The box is built with butt joints and has a sloping false bottom to hold the cards at a convenient angle. Strips to receive the glass are rabbeted on a circular saw or built up of three thin pieces of flat stock. File a finger notch on the right-hand edge of the box top to permit easy removal of the card.

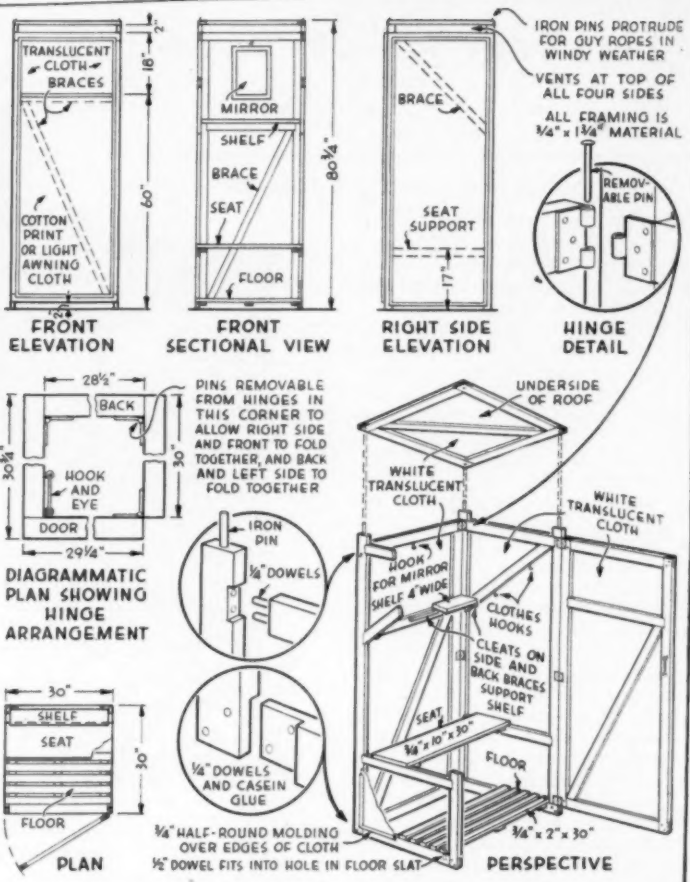
Build the box as a unit; then saw it in two to form the lid and the bottom. Care should be taken when assembling the box to keep all nails clear of the section where the cut is to be made. After fastening the hinges, insert the false bottom. Finish with paint or enamel.—FRANK HEGEMEYER.

Dear Workshop Editor.

Nowadays when health is so important, summer bathing at the beach has become so popular that it's sometimes hard to get a bath house. Couldn't you publish plans for making a light, portable dressing room to use right on the beach?

Yours truly,
A. R. M. San Diego, Calif.

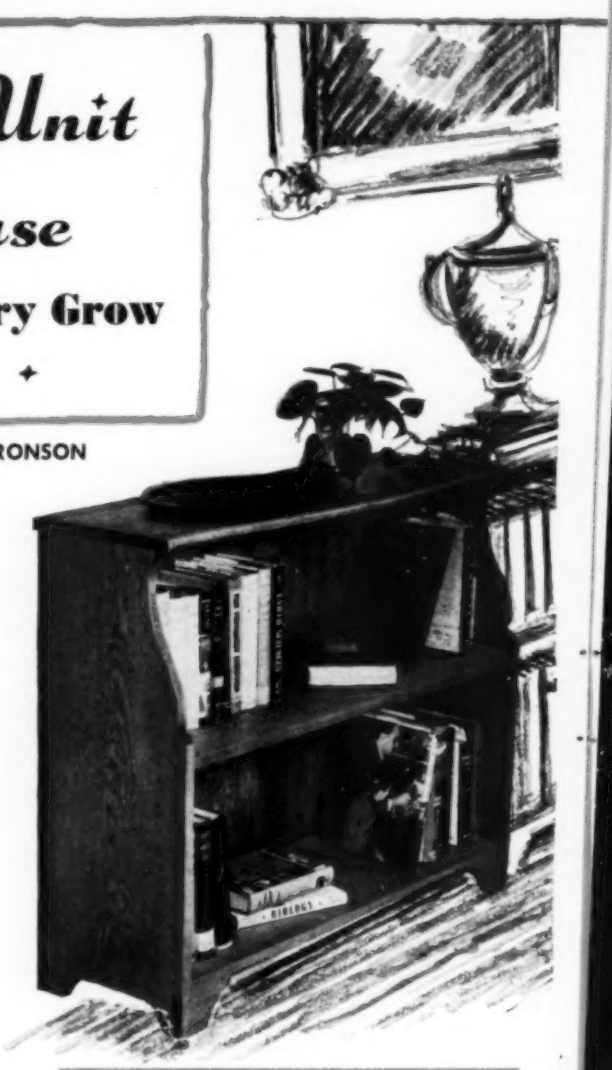
You'll be all set for a day at the beach with this bathhouse that can be folded into two easily carried sections. Designed by Hi Sibley



Add-a-Unit Bookcase

Lets Your Library Grow

✦ ✦ ✦ ✦



Designed by **JOSEPH ARONSON**

FURNITURE of the simplest kind of construction need not necessarily be of crude design. A bookcase made of plain shelving boards can be given refinement and interest by a few shaped lines at the top, sides, and front. This piece is designed so that it can be used either alone or in multiple, as shown in the accompanying illustration.

The original was made of 3′ lengths of common 12″ pine shelving. Such boards actually measure ¾″ by 11⅝″, and the accompanying bill of materials is based on these dimensions.

Both sides are cut to shape first, either on a band saw or with a compass saw. Next, the top is shaped in the same way, and its edge is molded with a plane or spokeshave. The sides are doweled, nailed, or screwed to the shelves. Both of the bracket feet are let into the sides.

Plywood is used for the back, being rounded off at all visible edges. It is nailed to the sides, and the ¾″ cleat is glued to the top.

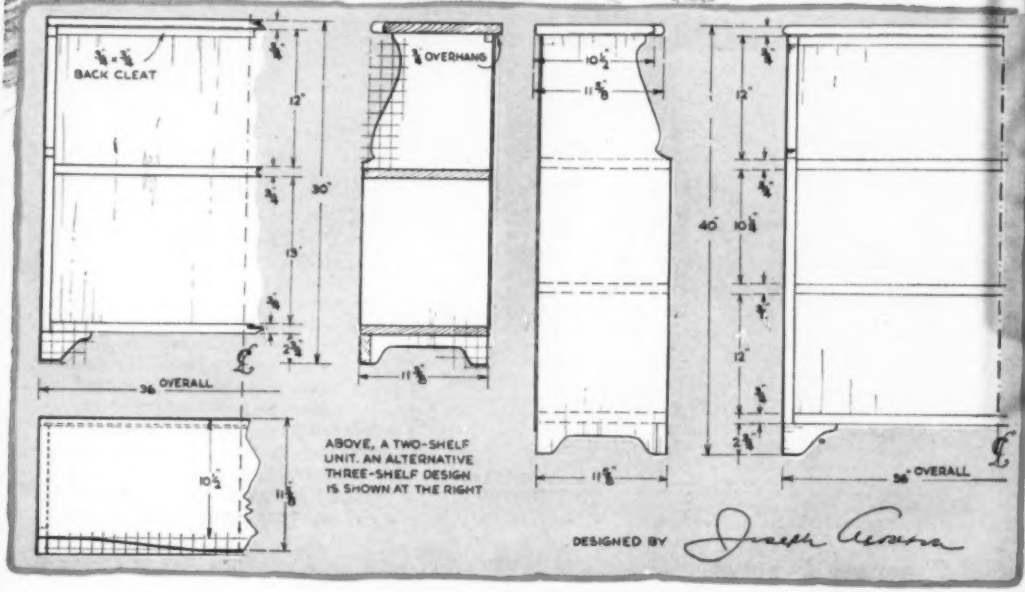
This bookcase is designed without an overhang at the sides so that two or more can be used together to form a harmonious grouping. These can be used to advantage in a room with much wall space. A three-shelf unit of the same pattern is suggested in the drawings.

After the construction is completed, the unit can be finished in any way desired—stained, varnished, or even enameled to match other home furnishings. If the wood has an interesting grain, it is a good idea to stain it only lightly in order not to conceal the grain.

LIST OF MATERIALS
Two-Shelf Bookcase

Pc.	Description	T.	W.	L.
1	Top	¾	11⅝	36
2	Shelves	¾	11⅝	34½
2	Sides	¾	11⅝	29¼
1	Back (plywood)	¼	26½	35
1	Back cleat	¾	¾	34½
2	Brackets (front feet)	¾	2¾	4½

Note: All dimensions are given in inches and are finished sizes.



ABOVE, A TWO-SHELF UNIT. AN ALTERNATIVE THREE-SHELF DESIGN IS SHOWN AT THE RIGHT

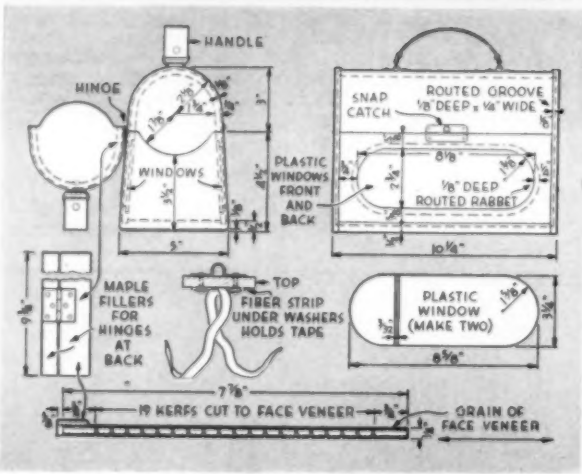
DESIGNED BY Joseph Aronson

For Your After-Hours

★ ★ ★ ★ ★ A WAR WORKER'S LUNCH BOX AND TWO OTHER

WAR WORKER'S LUNCH BOX. For saving time at war-plant gate inspections, this lunch box has clear-plastic window panes. It is made of waterproof plywood, ½" thick for the base and ¼" for all other parts. Saw the top and bottom of each end as one piece, separating them later with a band, jig, or scroll saw. The sides are alike, with openings jig-sawed and rabbeted for the panes. Use waterproof glue in assembling. Clamp the sides and ends first; then glue on and clamp the base.

Have the grain of the facewood of the top run in the direction of the shorter dimension, and cut kerfs as shown in the drawing. Curve the piece gradually in a vise or with a belt jig, dampening with hot, wet rags. This section is glued into grooves in the top endpieces. Attach the panes with cement and glaziers' points; then hinge the top and bottom at the glued-in fillers. Finish with two coats of waterproof varnish. Working time: 5½ hours.

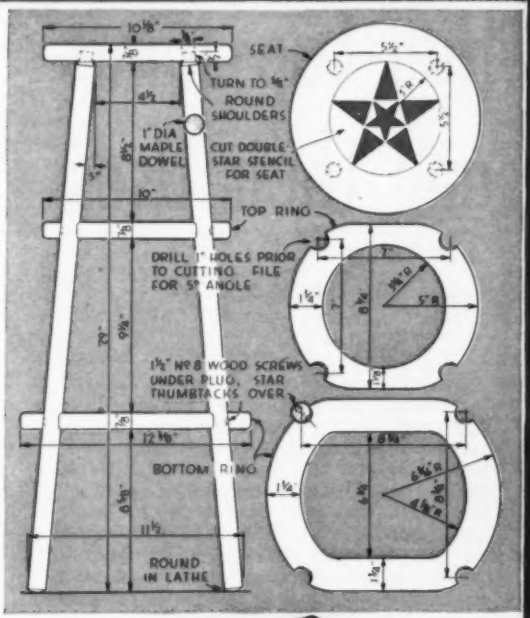


BAR STOOL. Here is an inexpensive way of making small, attractive stools for a breakfast or refreshment bar. Maple may be used throughout—1" dowels for legs and ⅞" stock for seats and spreaders. Glue the legs into the seats; then screw them to the spreaders, countersinking the screws ¼" and plugging the holes. Star-shaped thumbtacks over the plugs add a neat note. Finish with bright enamel; then stencil the star design on with a contrasting enamel. Two coats of varnish will preserve the finish. Working time: 5½ hours for one stool.

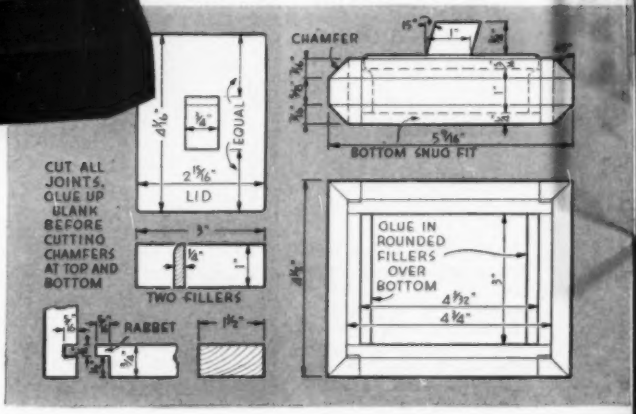
PAPER-WEIGHT BOX. Heavy walls and an angular design give this box a masculine touch. The stock may be cherry, walnut, or mahogany. Note that the ends of the longer walls are rabbeted and the others dadoed. Sand the inside of the pieces, assemble with glue, and chamfer the top and bottom edges. Make the base a snug fit and glue it in at the table line; then glue in the round-

Craftwork

PROJECTS OF REAL UTILITY ★


SEAT
TURN TO ⅛" ROUND SHOULDERS
1" DIA MAPLE DOWEL
CUT DOUBLE STAR STENCIL FOR SEAT
TOP RING
DRILL 1" HOLES PRIOR TO CUTTING. FILE FOR 5° ANGLE
1½" No 8 WOOD SCREWS UNDER PLUG, STAR THUMBTACKS OVER
BOTTOM RING
ROUND IN LATHE

DESIGNED BY
ERNEST R. DEWALT



ed fillers, which support the loosely fitted top and strengthen the base joints.

Sand the outside, rounding all edges. Spray or brush three coats of clear lacquer on the outside, rubbing with fine steel wool between coats. Wax several times for a sheen. Be careful to get no finish on the inside, which is left natural. Working time: 4 hours.

WHAT YOU SHOULD KNOW *about* Half-Lap Joints and Their Uses

By EDWIN M. LOVE

JOINTS made in building a mirror frame, cupboard door, and the like must be solid to give the piece rigidity and permanence. The half-lap joint proves satisfactory for this type of work and also for assemblies that must be taken apart occasionally. This joint consists of two members notched to half thickness and lapped on each other with the faces flush.

Most common of these joints is the end lap in which the ends of two pieces of wood are notched and cut to fit. In preparing the stock to be used, true it up and mark the working faces and edges with a sharp, hard pencil or a knife. Measure the width of the first member and mark it off on the second

Rip the cheek of a tenon by starting at the corner and sawing diagonally to the shoulder line. Then reverse the block in the vise and again saw from corner to line. The saw is steadied by the waste as these cuts are made

Two bench hooks support the member as the tenon shoulder is cut. Start making the saw cut at the farthest edge and, as the kerf extends across the wood, level off the saw. The block of waste wood will now fall out.

with a square, allowing a little extra length for the tenon. Repeat the procedure on the first piece, but mark it on the back. Using a marking gauge, scribe the depth of the joint on the edges and end of each piece. This measurement should be half the thickness of the joining members.

The notched surfaces of the tenon are known as the cheeks, and these should be ripped first. The reason for this is twofold: first, the waste stock supports the saw as it cuts to the bottom of the tenon, and second, there is less likelihood of cutting into the tenon thickness, as the waste block falls away when the shoulder of the joint is cut. Clamp the piece upright in a vise. Then saw down from the near corner diagonally to the line marking the shoulder of the joint, keeping the saw kerf in the waste. Complete the cut by reversing the piece and sawing in the opposite direction. If you have no vise, or if the stock is too long to be handled conveniently in this manner, rest it edgewise on a sawhorse and rip the cheek from one edge and then the other, handling it like an ordinary board.

In cutting the shoulder to remove the waste block, brace the wood on a pair of bench hooks. Start the cut at the far corner and level off when the kerf extends across the stock so that the tenon will not be partly sawed through before the block is detached.

Joints of this type can be glued, screwed, or nailed. In gluing, apply the binder on both joining cheeks and hold them together with a clamp. Tap the edges in order to close the shoulder joints. If the lap is to be screwed, bore and countersink holes in one tenon and, if the material is hardwood, use this tenon as a template for locating pilot holes to be drilled in the other.

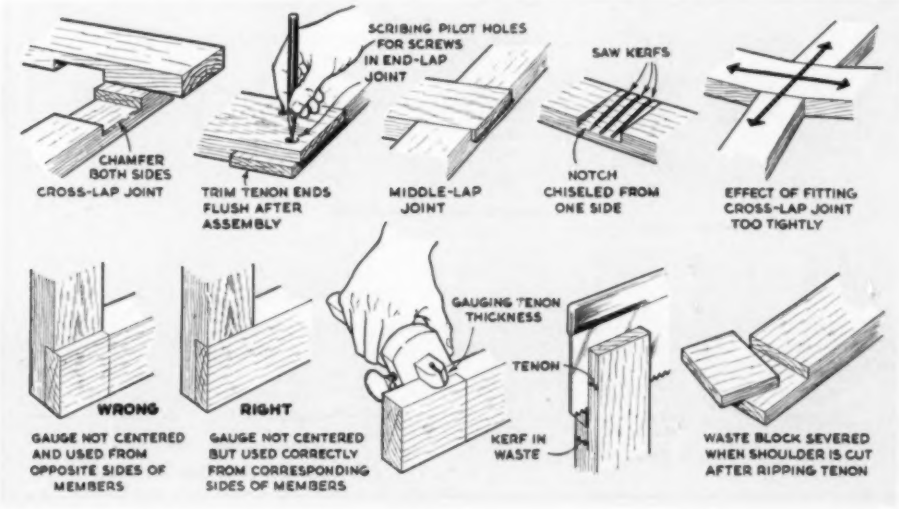
Such structural forms as X's make use of cross-lap joints, in which both pieces are notched between the ends. Extra saw cuts in the waste, made to the depth of the joint, make it easy to trim flat bottoms. Use a sharp, wide chisel with the bevel down, and make tapering cuts from both edges. This avoids splintering of the far edge that would occur if the cut were made full width. True the bottoms with the flat side of the chisel down.

Small joints can be trimmed with hand pressure and a side swing of the chisel handle, but larger work requires a mallet. If none is available, follow carpentering methods and strike with the side of a hammer head.

In order to avoid any chance of the edges of the boards not being parallel, hold one piece firmly in place on top of the other and run a knife along its edges when marking the shoulder. This will assure the correct angle at the intersection also.

The sharp corners of a snugly fitted joint tend to tear the edges when it is being assembled. To avoid this, chamfer the edges of the bottom of the cut. While it is most desirable to have tight joints, little force should be used in fitting the pieces together. When they are wedged too tightly, both members will bend back, throwing the work out of line, as one of the drawings shows.

A joint formed by a notch cut in the middle of a member and a tenon cut on the end of the other member, is known as a middle-lap joint. The methods of cutting the two pieces are the same as for the end


CHAMFER BOTH SIDES
CROSS-LAP JOINT
SCRIBING PILOT HOLES FOR SCREWS IN END-LAP JOINT
TRIM TENON ENDS FLUSH AFTER ASSEMBLY
MIDDLE-LAP JOINT
SAW KERFS
NOTCH CHISELED FROM ONE SIDE
EFFECT OF FITTING CROSS-LAP JOINT TOO TIGHTLY
WRONG
GAUGE NOT CENTERED AND USED FROM OPPOSITE SIDES OF MEMBERS
RIGHT
GAUGE NOT CENTERED BUT USED CORRECTLY FROM CORRESPONDING SIDES OF MEMBERS
GAUGING TENON THICKNESS
TENON
KERF IN WASTE
WASTE BLOCK SEVERED WHEN SHOULDER IS CUT AFTER RIPPING TENON

lap and cross lap that are described above.

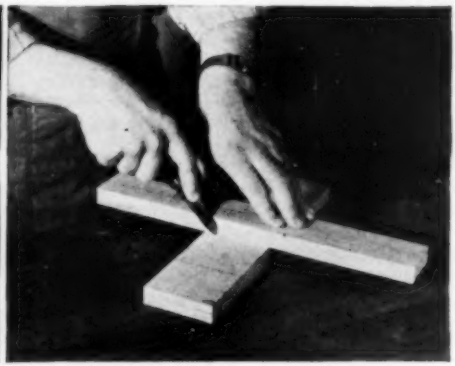
A refinement of the half-lap joint is the mitered lap. In this, the end of one member is mitered and half the thickness of the mating piece is mitered, the remainder forming a tenon. The method of cutting is the same as for square joints. Miter angles need not be 45 deg.; for instance, the joint might be a union between a door stile and a wider lower rail, or it might join together parts of a hexagonal frame.

Blind half-lap joints, designed to hide end wood, can be made with little extra effort. The easy way is to cut one tenon short, and fill the remaining space with a dutchman cut extra thick and glued in. When the glue has dried, trim the filling flush. While this is adequate for paint finishes, the workmanlike way to do the job is to chisel out the one cheek instead of sawing it so as to leave a continuous edge that will hide the other tenon end. Saw the shoulder to depth at the open edge; then trim to depth at the back with a chisel held vertically.

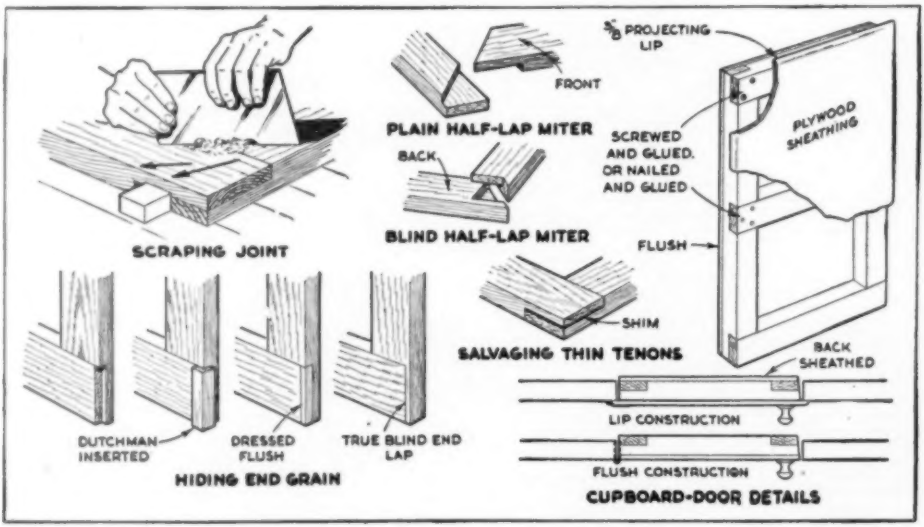
If the joints have been cut accurately, they should assemble with the faces flush. Usually, however, a little surfacing is needed although it may be only sandpapering. In rubbing with sandpaper, be sure to stroke along the grain, as cross sanding shows up in stain and varnish and even in enamel. If planing is necessary, use a smoothing plane set fine, and stroke diagonally in order to avoid tearing the wood. If the wood is hard, a scraper is excellent for this purpose.

When the tenons have been cut too deeply,

To remove wood in the notch, hold the chisel with the bevel down. Cut in and upward from each edge



This method of scribing a line insures accurate measurement even though the sides may not be true



insert thin sheets of wood between the cheeks of the joint. If the joint is being glued, apply the glue to all contacting surfaces. In joints that are held with screws, use cardboard as a shim. If the joints are too tight, plane a shaving from the edges; if they are too loose, a skillfully made dutchman wedged in may hide the effect. Obviously, such salvaging should be done only as a last resort, as every effort should be made to cut joints that fit accurately.

Excellent flat-surfaced cupboard doors can be built cheaply by assembling frames with half-lap joints and sheathing them with ¼" or ⅜" plywood. These can be made in two different styles—lip doors and flush doors. In a lip door, the plywood projects at the edge and hides the joint between the frame and the cabinet opening, whereas the plywood on a flush door is trimmed to the frame so that the front is even with the front of the cabinet. In making the lip type, build the frame to fit the opening, allowing a clearance of as much as ⅛" all around. The flush door should be built nearly the same size, allowing for jointing the edges for a clearance of about 1/16" all around.

Before applying glue, make a trial fitting of the joints by clamping them together to make sure that all edges fit firmly and that the faces are flush. When the glue has dried, remove any excess with fine sandpaper. Be especially careful to leave none under the lip, or on the edges of a flush door.

When the surfaces of the joint are not flush, use a smoothing plane on them, but stroke diagonally so as not to rip the wood

ELIMINATING DOOR FRICTION

[*SHIPSHAPE HOME*]

Door drags on floor. Tighten the screws in the hinges, especially in the upper one. If screws have pulled loose, drive glue-coated wooden plugs into the holes, or tamp them full of steel wool, and turn the screws in. If composition wood is used, drive a wedge under the door until the screws are set.

If this treatment does not clear the binding, a cardboard shim may have been put behind the hinge. Remove this and tighten screws.

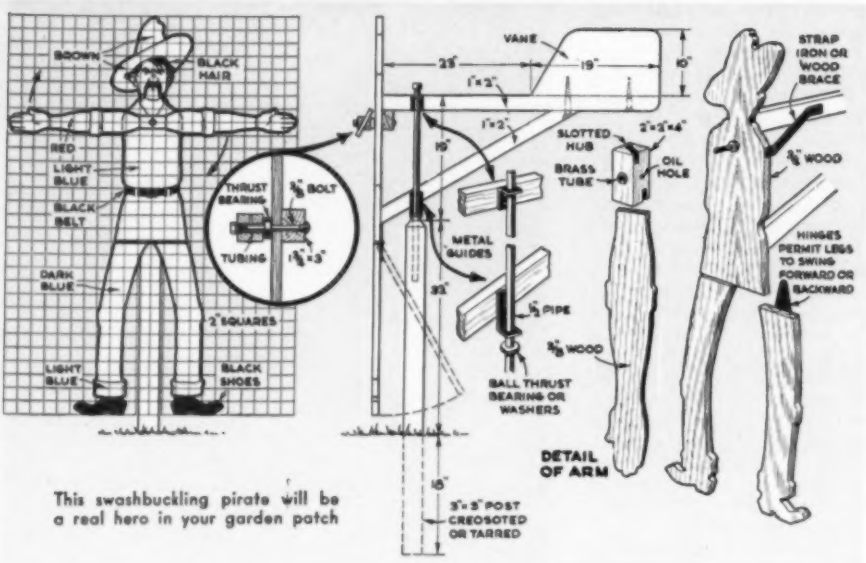
Door binds on lower end of lock jamb. If tightening the lower hinge is insufficient, hold a block against the jamb and strike with a heavy mallet or hammer, lightly at first, harder if necessary.

Door rubs side or head jamb. Try driving the jamb at these points. If the jamb was well blocked when installed, this driving will move it very little, but often a slight shift will clear the door.

Upper lock corner rubs. This is easily planed down, and the bare wood may be stained or painted.

POPULAR SCIENCE MONTHLY SHOP DATA

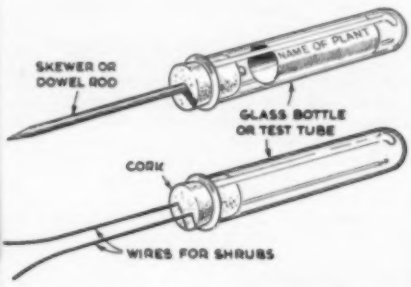
Animated Scarecrow Frightens Birds from Your Vegetables



A SCARECROW with spinning arms and dangling legs will help frighten birds from your Victory garden. Short lengths of board and odds and ends from the junk box are all the materials needed for building one.

The head and torso are cut from a piece of ¾" stock, and a heavy piece across the shoulders serves as both a cleat and a support for the bolt on which the windmill arms turn. These revolving arms are fastened into a slotted hub, with a short length of brass or copper tubing set in it for a bushing. Both legs are hinged to swing backward, and the vane is supported on wood members to which are screwed guides for the vertical axis made of ½" pipe.

Paint the scarecrow as shown in the drawing, or make up your own color scheme. A realistic flesh color can be made by mixing red, yellow, and white paint.

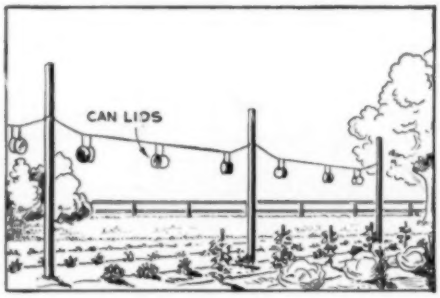


Markers for Flower Planting

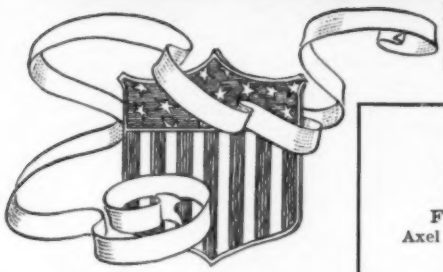
GLASS tubes containing slips torn from paint color cards make good markers that show the hue of the bloom as well as the name of the plant. They can be stuck in the ground or tied to stems.—E. C. HANLEY.

Can Lids Protect Your Garden

COFFEE-CAN lids, paired 2" apart and suspended in a series, will effectively frighten away birds and other garden marauders. Pairing up lids of different sizes will result in different tones. The lids can be strung on wire or on heavy, waxed cord.—H. S.



Present at judging of the entries were, left to right: Wesley Reeve, Coast Guard; S. C. Westfall, Army; Harry Walton, Home and Workshop Editor; Warren Kennedy, Navy; and Donald J. Gilchrist, Royal Canadian Air Force



Six Craftsmen Win Prizes in Our SERVICE MEN'S GIFT CONTEST

FIRST PRIZE, $50
Axel E. Ogren, Chicago, Ill.

SECOND PRIZE, $25
H. A. Schulz, Milwaukee, Wis.

THIRD PRIZE, $10
Ralph Dickenshied, Two Rivers, Wis.

FOURTH PRIZE, $5
Leo Domzalski, Jr., Chicago, Ill.

FIFTH PRIZE, $5
Harry Lieberman, Evansville, Ind.

SIXTH PRIZE, $5
Joseph Brtan, Bordentown, N. J.

FOUR service men, representing the Coast Guard, the Navy, the Army, and the Royal Canadian Air Force, assisted the editors in judging the many entries in our Service Men's Gift Contest (see P.S.M., Feb. '43, p. HW 521).

A unique shoe polisher containing dauber and polish won first prize in the contest. This entry combined utility with compactness, two qualities well worth remembering when you design gifts for boys in the service. The polisher, formed from a block of pine, has a hinged top covered with soft buffing material. When closed, this top forms the polishing surface. Cut-outs inside the block hold both polish and daubing brush.

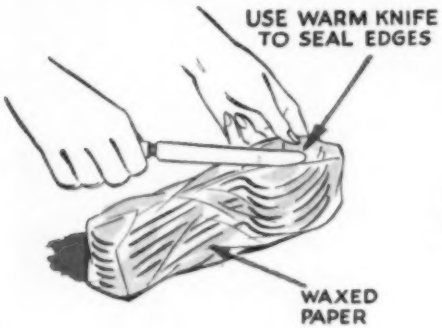
Other prize projects included a pocket picture frame of leather with a tooled design, a novel game played with wooden pegs, a sea-bag hook that can be locked, a useful toilet kit, and a writing pad with a small battery lamp built in so that letters can be written on the pad outdoors at night, or in a darkened room.

The prize-winning items will be described in forthcoming issues of POPULAR SCIENCE.

Although utilitarian gifts are warmly welcomed by service men, games, puzzles, and the like also come in for their share of interest, for these help the boys spend their leisure hours while in camp. All games, however, should be compact and not too complicated.

Another thing learned from the contest was that elaborate, luxurious gifts are not necessary. The winning entries were all simple in design and extremely functional. Expensive-looking trappings are scorned by men in the service—gifts should be made with an eye on practicality and usefulness.

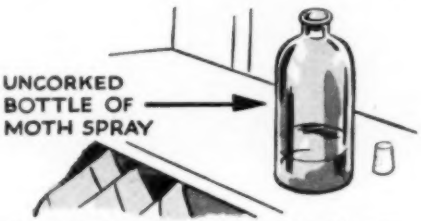
KEEPING THE HOME



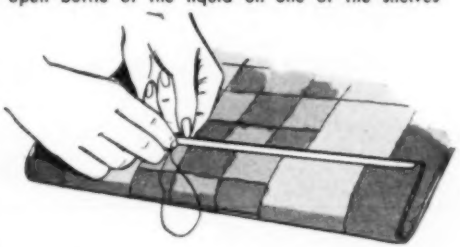
Silverware is tarnished by sulphurous gases in the air. To protect it, wrap it in waxed paper and seal the edges of the paper by pressing a hot knife along them so that the wax melts together

Space can be conserved in the kitchen of a summer cottage if the bread box is mounted underneath one of the shelves. An auxiliary shelf nailed inside the box will accommodate smaller items

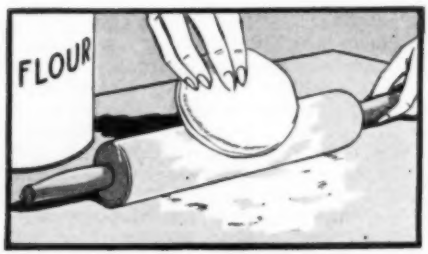
Nail-polish remover dabbed on paint marks will serve as an efficient substitute for turpentine. It should be wiped off while it is still wet



Fumes evaporating from a bottle of moth spray will keep moths out of a closet. Just place an open bottle of the liquid on one of the shelves



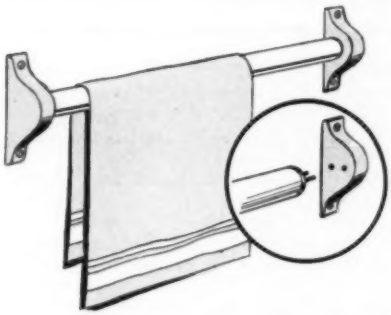
Corset steels can be used to keep light rugs from curling at the corners. Baste one under each edge



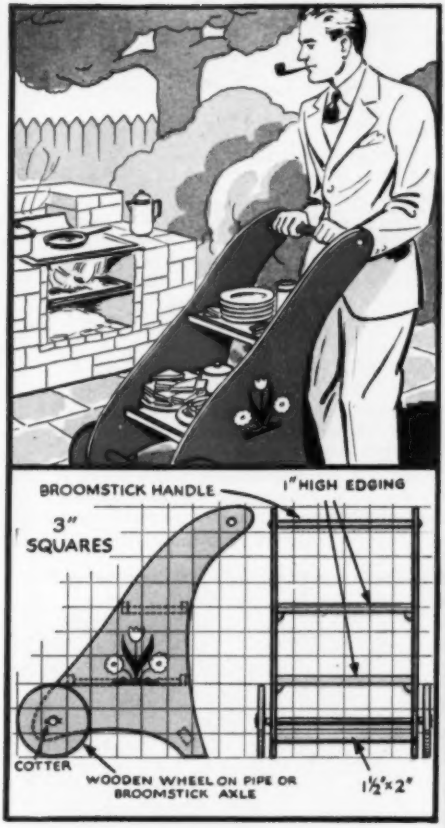
Powder puffs can be as useful in the kitchen as they are in the boudoir. A large one placed in the flour canister will come in handy if used to dust flour on the rolling pin and pastry board

SHIPSHAPE

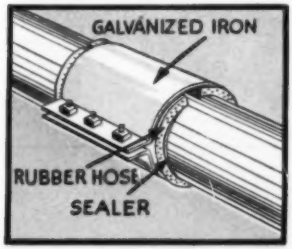
To clean the sweatband of a man's hat, insert a pad of cheesecloth between band and felt; then rub the band with a pad wet with cleaning fluid



Attractive towel racks can be made from discarded fluorescent tubes. Simply drill two holes in each of a pair of wooden blocks and attach the blocks to the wall with screws. Longer tubes may be used in the bathroom and shorter ones in the kitchen

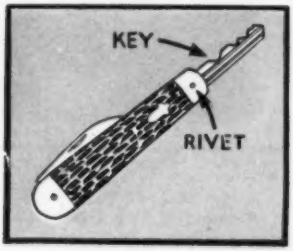


A chuck wagon for back-yard serving can be made from ½" plywood and scrap lumber. A 1½" by 2" by 18" wooden stretcher fits between the sides and a 19" broomstick serves as a handle. Two wooden wheels ½" thick and 9" in diameter are held in place with cotter pins on an axle made of ½" pipe. Parts are assembled with nails and glue



Leaking pipes can be sealed with a gasket compound. Cover with a piece of old rubber hose. Secure with a clamp made of sheet metal

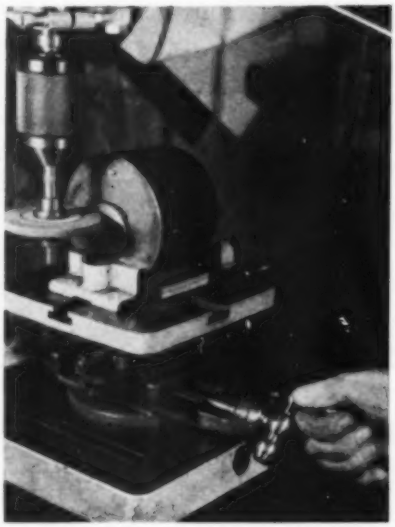
Squeaky rubbers can be silenced by sprinkling talcum powder inside them. It is best to spread it around evenly with a small cloth



If a pocketknife blade breaks, drive out the rivet and put your house key in its place. The key will then be handy at all times

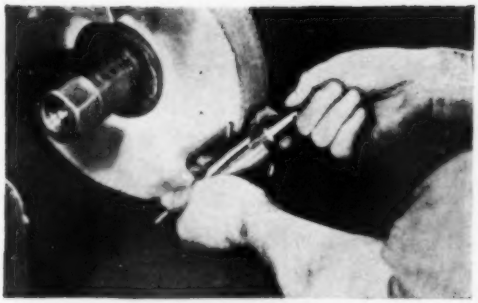
NEW SHOP IDEAS

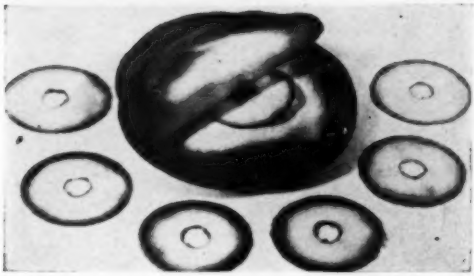
SETTING SPARK-PLUG GAPS is done automatically by a machine invented by Frank LeVoci, tool-room foreman and POPULAR SCIENCE reader. This device enables 10 workers to adjust as many plugs as 50 could set in the same time by hand. The machine consists of an arbor press with one lever attached to the pinion acting as a ram, and another manually operated lever pivoted on the pinion. Both levers are connected by an electromagnet. A tool held in the ram bends the four ground prongs toward the center electrode. When the gap has been established, the circuit breaks and no further pressure is transmitted.



Above, how a steel disk is held for surface grinding by a magnetic chuck made out of a loudspeaker field coil. The space between the magnet core and housing was filled with a cardboard ring (right). In a photo on the facing page a triple-pole, double-throw switch was used. The center poles were not connected, and the others were hooked up as shown in the drawing. To free work, reverse the current for just a fraction of a second

A MAGNETIC CHUCK made from an old loudspeaker field coil was found to be the answer to the problem of surface-grinding a number of steel disks that could not be held in an ordinary chuck. The coil, found in a box of junked radio parts, was designed to operate on a 6-volt battery and drew 1 amp. First of all, the coil housing, a steel shell with a disk-shaped "lid," was stripped of all unnecessary appendages. Fillister-head bolts holding the lid in place were replaced by bolts with countersunk heads. The ring-shaped groove that held the voice coil was filled with cardboard impregnated with household cement. Then the coil unit was clamped to the milling table of the drill press in such a way that the surface holding





BUFFING OPERATIONS can be simplified if worn buffer disks are cut to half their original diameter and then used as spacers between the disks of new wheels, as shown in the accompanying photographs. The resulting air space between each layer of material causes the cutting compound to dry more quickly. Less compound is used, less pressure is required, and the cutting is much faster. With this method, sunken and intricate surfaces can be much more easily reached without forcing the wheel unduly.—VINCENT A. GUERIN.

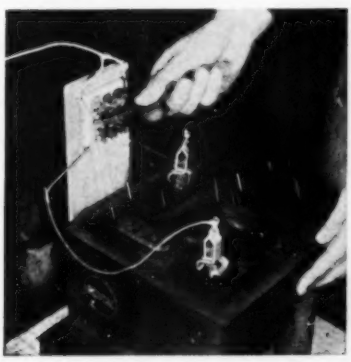
DRAFTSMEN often have trouble in drawing very small circles with an ordinary bow pen. I have found that bending the point toward the pen solves this problem. In drawing very small circles, first prick the center hole with another point; then apply the pen. Using this simple system, one can draw circles as small as 1/32" in diameter and they will still be perfectly accurate.—S. M. TILTON.

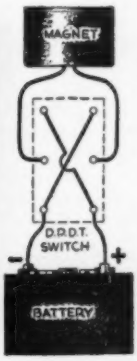
the work would be in a vertical position. The grinding wheel on an arbor in the drill chuck rotated in a horizontal plane.

Current from a 6-volt automobile storage battery flowed through a polarity-reversing switch to the magnet. The double-throw switch was wired as shown in the drawing, and although not absolutely necessary, is handy for releasing work instantly.

This improvised magnetic chuck had more than ample holding power for the disk-grinding job. It was found adaptable to various other kinds of grinding and machining on the drill press.

When the magnet was mounted in its final position, the work-holding surface was trued up by taking a light cut over it with the grinding wheel.—WALTER E. BURTON.

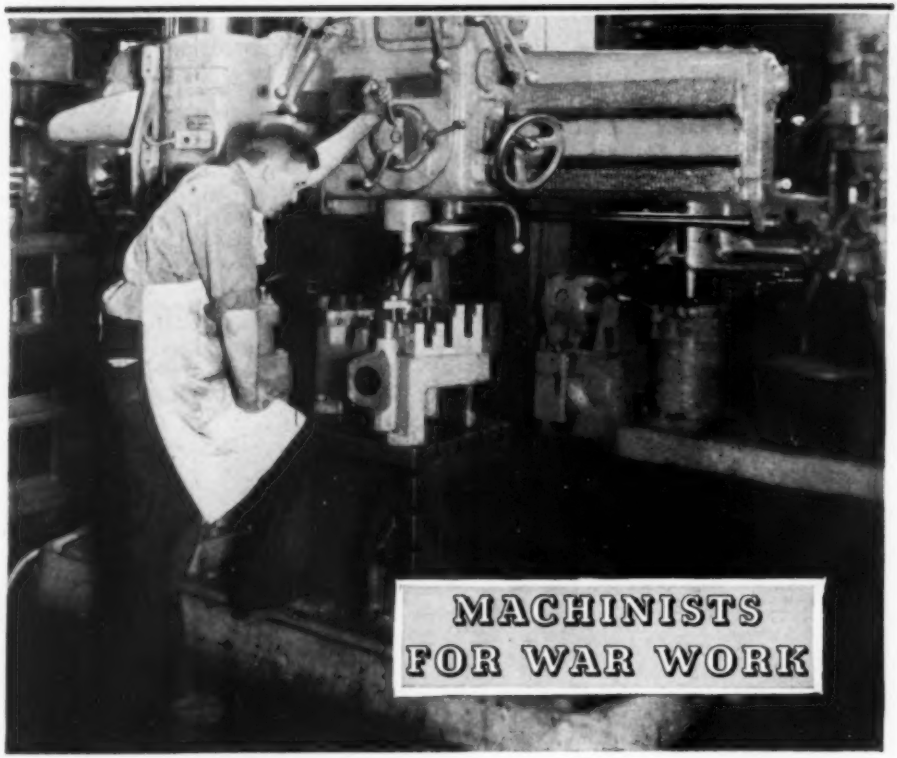




THE PORTABLE BLOWER shown above was made from junked parts by Bill Hesh of Santa Fe, N. M. He used an old ¼-hp. electric motor as the power unit, fitting to it a discarded auto fan. To make a base, he bolted an old axle housing to a brake drum. A large pipe or a portion of a drive shaft would do as well. The motor base was attached to the top of the housing in such a way that it could be tipped up or down. A sheet-metal drum was built around the blades and fitted with guards welded together of rods.

USING THE MODERN RADIAL DRILL

HOW HOLES ARE SPOTTED WITH PRECISION JIGS IN DUPLICATE WORK

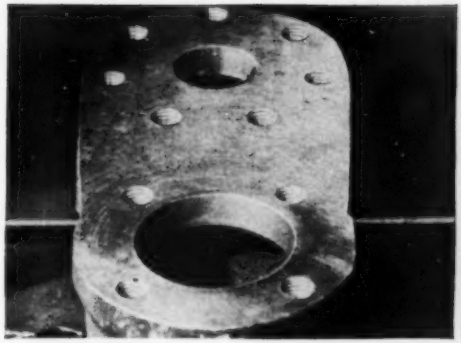


THOUSANDS of American men and women who had not even seen a machine tool a few years ago are today working on production lines with modern equipment that speeds the stocking of our arsenal of democracy. Among these machines for mass production of duplicate work is the radial drill, one type of which is shown in the photograph above. Used with a precision jig, it is capable of drilling and tapping a succession of holes in a metal casting with one clamping of the work. This is particularly valuable where work is too large for moving about and is to be duplicated in thousands of pieces.

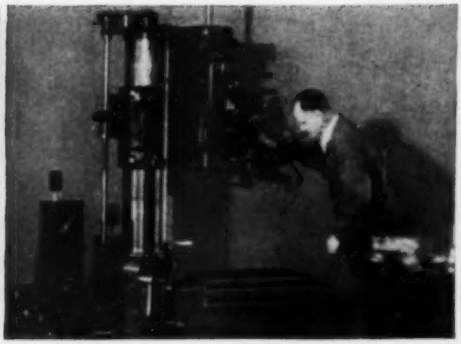
One of the chief advantages of the radial drill over the drill press commonly found in home workshops is its horizontal arm, which can be swung radially about its upright standard and carries a spindle that can be slid back and forth on it. It is this movement of arm and spindle that permits drilling successive holes without shifting the work.

For precision, and to save the time required to lay out holes individually on each piece, the jig comes into play. This is usually made by an expert toolmaker, who locates, drills, and sometimes grinds the holes that guide the bit into the work. These holes are made to fit a hardened steel bushing, which in turn fits the bit to be used and keeps it from marring the jig. Either the same bushing may be used for all holes, or each hole may be provided with one.

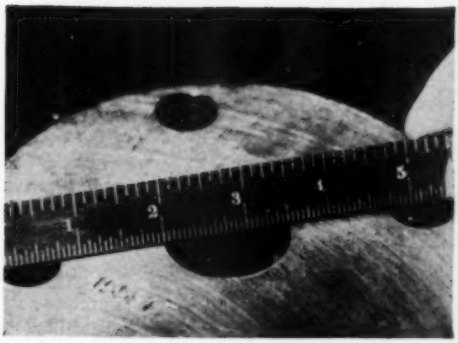
Photographs on the three succeeding pages show the operations in drilling and tapping blind holes on two sides of a cast-steel valve body. They were selected from one of the 35 sound films prepared by the U. S. Office of Education and distributed by Castle Films to Government and industry-fostered schools for war machinists.



1 This is a typical radial-drill job. Several hundred valve bodies are to be drilled for 11 ⅛" tapped, blind holes, top and bottom. These are to be made ⅞" deep with a 17/32" tap drill



2 With the arm swung out of the way for safety, the operator cleans the table of dirt, chips, and burrs. This will keep the holes straight and will prevent breaking the bit during the drilling

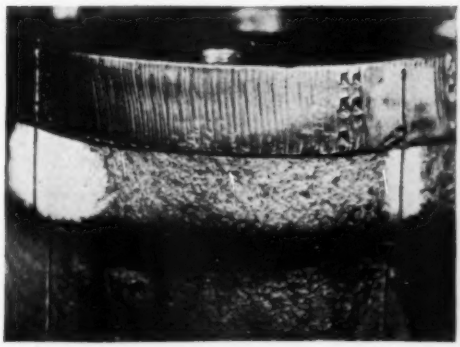


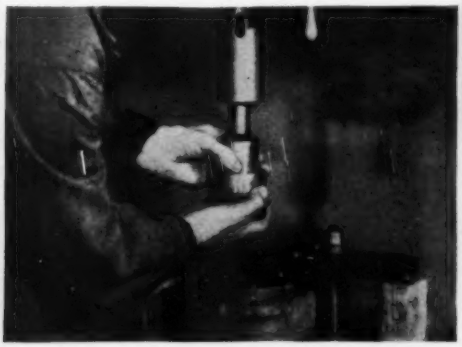
3 When he receives the drill jig, the operator checks the number to see that it corresponds to the one ordered for the job, and as an added precaution he also measures the holes in the jig

4 Next, the operator places the valve body on the table, being careful to avoid damage. He fits the jig to the work and clamps both securely to the table with two hold-down clamps and blocks

5 Scribed lines were previously laid out on the casting so that the jig could be located in its proper place. In the photograph below, note how these lines coincide with those on the jig

6 After the job has been set up (note bolts are near the work for maximum leverage), a drill chuck of right size and taper is chosen, the tang is lined up, and it is pushed into the spindle

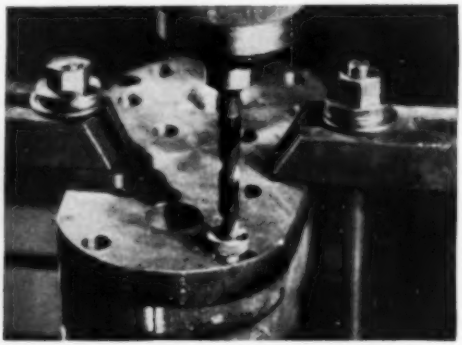




7 The correct size tap drill is next selected and set into a friction chuck, which puts a limited torque on the bit while it is running in the casting. This prevents breakage if it jams

8 Since the blind holes in the casting are to be drilled 7/8" deep, the spindle stop on the drill head is set at 7/8" on the scale in order to arrest the feed automatically at that depth

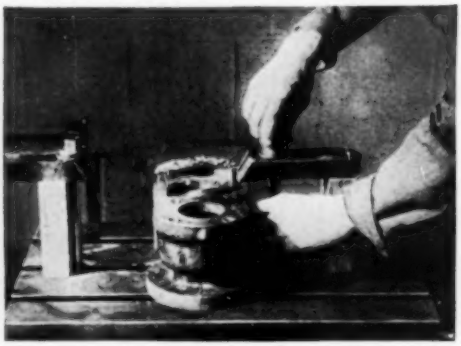
9 Reference to the handbook shows cast steel should be drilled at 350 r.p.m. when a 17/32" high-speed drill is used, and feed should be .007" per revolution. Gears are set for these rates



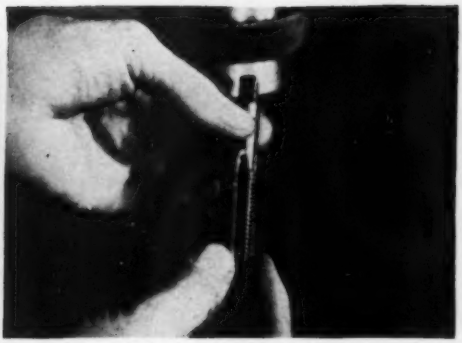
10 With a hardened bushing on the bit and resting on the jig, the drill head is moved about until the bushing drops into a hole. Arm and head are locked, and drilling is begun with hand feed

11 As soon as the bit has made a good start, the spindle is raised by hand, the bushing is removed, and drilling proceeds with automatic feed. All holes on one side are drilled this way

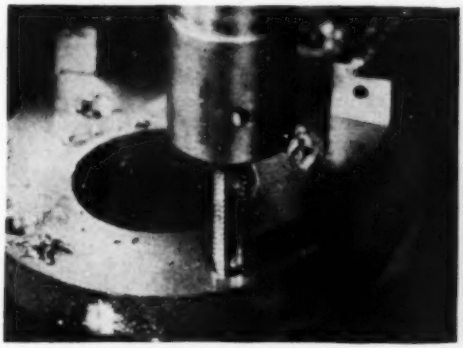
12 The clamps are loosened, the jig is removed, and the table is cleaned. A plate of the thickness of the jig is put under the work and the same blocks are used to clamp it for tapping



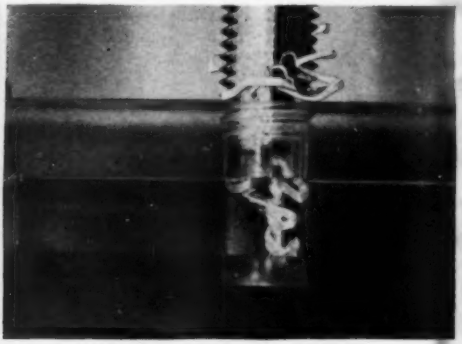
13 Burrs are filed, and each hole is carefully cleared of chips. This may be done with a piece of magnetized steel. It is dangerous to blow chips from the holes with shop air pressure



14 A tap of the size and shape required for the job is then selected. This is used with a friction chuck, which will slip if the hole loads with chips, and will keep the tap from breaking



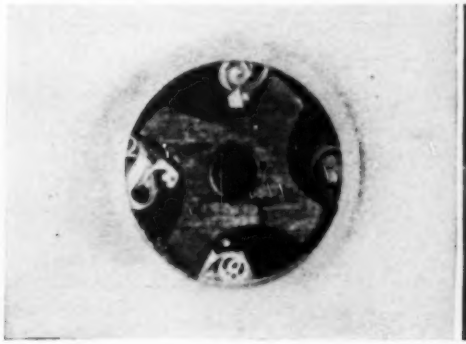
15 With the drill arm and head loosened, they are shifted until the tap centers itself in the hole; then they are clamped. In tapping, the spindle is fed by hand, not by the automatic feed

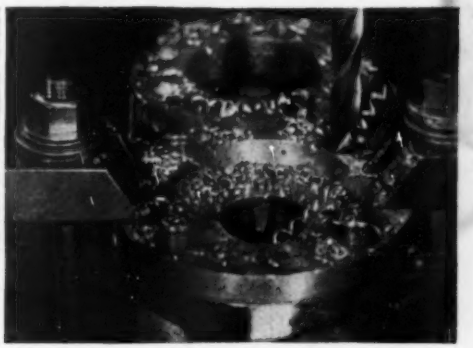


16 Tapping in clear plastic shows the cutting action. Chips form in the flutes and drop down in the hole. The tap must be backed out for occasional removal of these in tapping blind holes

17 This view from the bottom of the plastic shows how chips curl in the flutes, slowing the tap and making rough threads. They may be broken loose by backing up the tap a half turn

18 When tapping on one side is completed, burrs are filed off, the table is cleaned, and the casting is turned over. All steps in drilling and tapping are then repeated for the second face





Watch Those Bearings

TO KEEP SHOP MACHINES ON THE JOB

By JOHN MODROCH

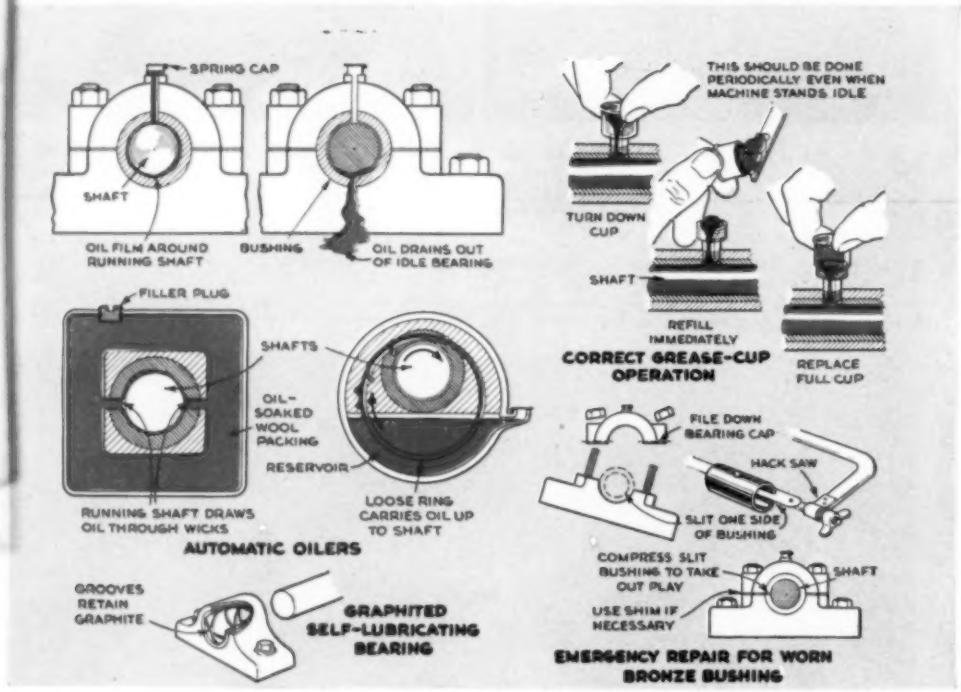
THE first requisite of efficient bearing maintenance is proper lubrication. Bearings are built to run in high-quality lubricants that are free from alkali or any other ingredients that might be injurious to the metal parts. Oil and grease are most commonly used.

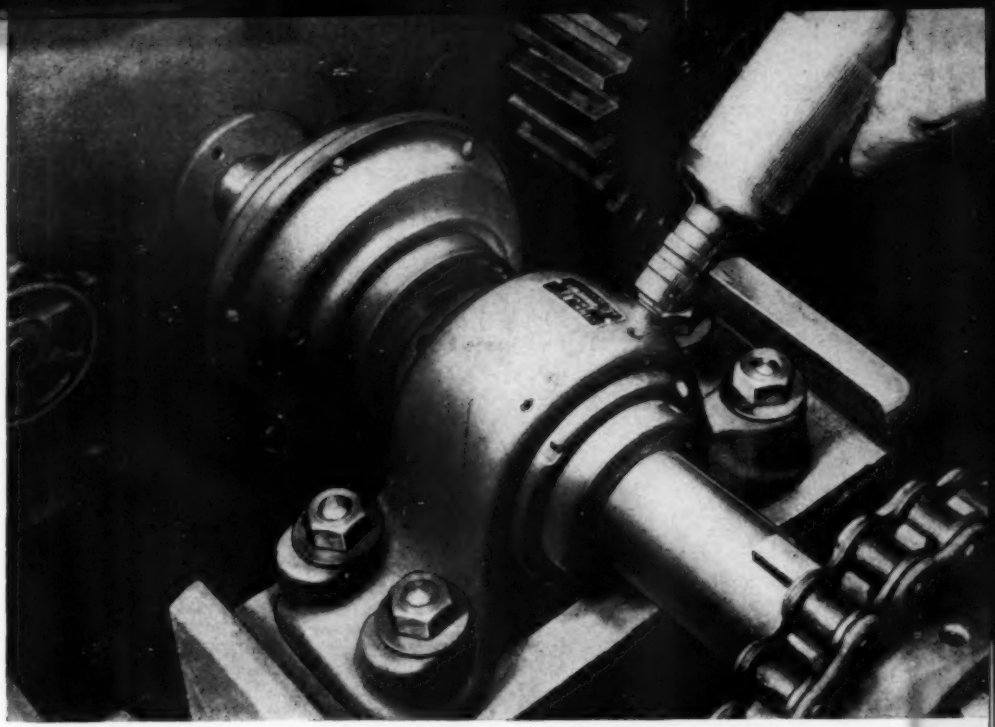
Hand oiling should be done sparingly before the machinery is put in motion. Cold bearings do not absorb oil readily, and the excess is therefore thrown out for the first few revolutions. Thorough oiling by hand can be done after the machinery has been running for a while and the bearings are warm.

Belt guards should be made of wire netting or some similar material in order that the bearings under them may be seen and also to provide ventilation. Check the performance of newly installed bearings with and without a full driving load. Bearings should run only warm—never hot. Smoke, a burning smell, or a rattling noise is a danger signal. If you notice any one of these, stop the machine as quickly as possible and oil the bearings thoroughly while turning the shaft by hand. Wait until the bearings cool before starting the machine again. A slipping belt may also be a sign of a binding bearing.

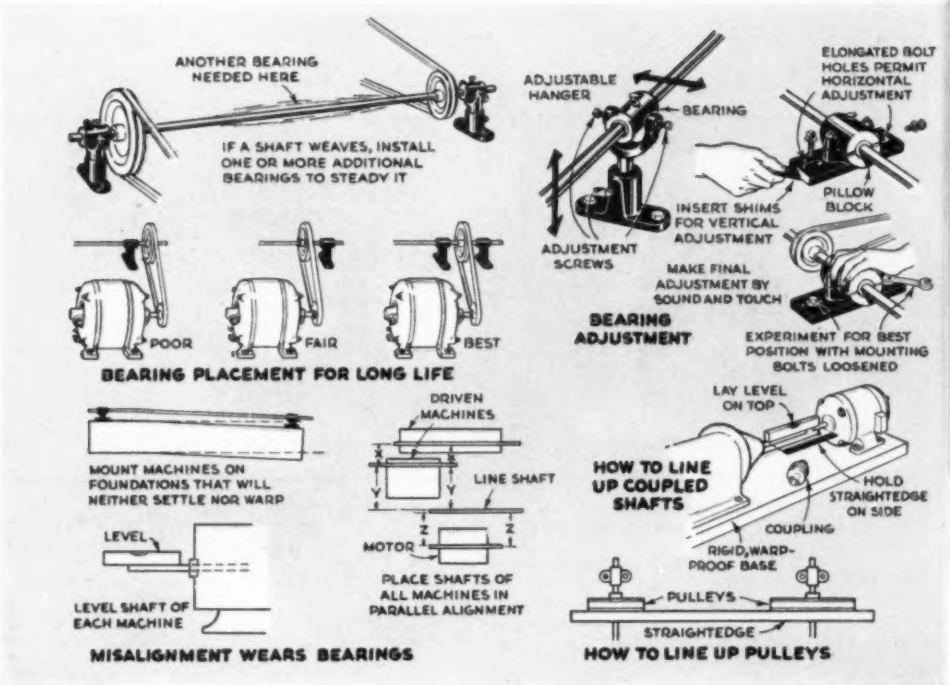
Belts should be no tighter than is necessary for positive traction. As a rule, V-belts require less tension than flat belts to prevent slipping. Because canvas belts have a tendency to contract or stretch under certain weather conditions, they should be checked for proper tension frequently.

YOU CAN HELP KEEP PRODUCTION ROLLING BY FOLLOWING





THESE PRACTICAL POINTERS ON BEARING MAINTENANCE



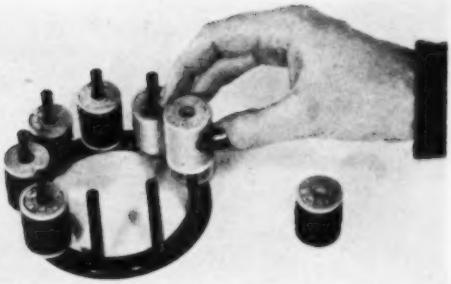
AIDS TO WARTIME *Housekeeping*

AUTOMATIC HOSE MENDER. This convenient gadget reknits runs in hosiery and lingerie with the same stitch as the original. It uses no thread and is said to be extremely simple to learn to operate. The stocking is placed over a small glass, and thus held firm and taut while it is being mended

PAPER is now used as a substitute for some of the critical war materials. The clock case shown above is made of a cellulose fiber treated so that it is impervious to humidity. Below, burlap made of tightly twisted kraft paper is both flame and water resistant. It is being used in wrapping airplane parts

THESE BATTERY LAMPS are convenient for children's rooms, tents, camps, porches, farm buildings, dim-outs, and for emergency use when electric power fails. They work on three standard flashlight cells. Both styles shown are 15" in height, with 9" shades. Bases and shades are enameled white and are available in both a plain and a handsome gilt-decorated finish. Both shades are mounted on swivels so that they can be adjusted to any angle

SHOES CAN BE WATERPROOFED with a liquid that also lubricates the leather. It can be used on all shoes or boots that will take a polish, as well as on many other types of leather goods. One treatment is said to waterproof a pair of shoes permanently, but in order to lengthen the life of the leather, the fluid should be applied more than once. Shoes must be allowed to dry overnight, after they have been thoroughly coated with the liquid, before they are given a polish



COMBINATION SPOOL AND TIE RACK. Made of plastic, this rack measures 4½" in diameter and will easily fit into a sewing basket or drawer. The nine prongs are 2" high, and each one will hold two spools of thread. Several holes drilled around the base of the rack permit it to be mounted in a convenient place on the wall, where it may be used for holding ties or belts. Color choice is red, green, or blue

HOUSEHOLD LABELS, 500 of them designed to meet virtually all household labeling needs, are contained in the handy book shown in the photo below. Included are labels for canning, mailing, marking photographs, storing boxes, and many special types. The book is 7" by 10". All the labels are gummed and perforated

A CHAMOIS SPONGE has been developed that has many uses both as a chamois and as a sponge. It is ideal for washing windows, mirrors, furniture, painted walls, automobiles, carpets, and for all general household use. Small pieces of oil-tanned chamois are sewed together in a cluster to make this durable sponge, which is thoroughly washed and all ready for use. No breaking in is necessary. It is available in two convenient sizes

LIQUID METAL CLEANER. Especially made for cleaning kitchen utensils, this fluid is said to do the work of steel wool. It may be used on aluminum, brass, stainless-steel alloys, chromium, bronze, porcelain, and copper. A sponge or cloth is moistened with the cleaner and the metal is rubbed gently until thoroughly cleaned. Nonpoisonous, the fluid may be used safely on both the insides and outsides of pots and pans. It is put up in Victory cans and comes in two handy sizes for everyday household use

Photography

Silhouettes

ADD DRAMA TO YOUR PICTURES

By James Wong Howe, A.S.C.

Jimmy Howe, an American-born Chinese, for the past 20 years has been a first cameraman, filming among some 100 features such recent pictures as "Air Force" and "The Hard Way." "The North Star," a story of Russia, is now unfolding before his camera on the Samuel Goldwyn lot.

SILHOUETTES and shadows are a magic formula for putting punch into both home movies and still pictures. We use silhouettes and shadows in professional movies to introduce characters, obtain dramatic effects, and establish moods.

How do you go about making silhouettes, both outdoors and in? Unlike the usual shot in which you expose for the shadows and shoot away from or across the light, silhouettes demand that you catch your subject when it is in shadow. You expose for the brilliant background, deliberately underexposing the main subject. The result is a sharp black-and-white contrast and an effective picture.

Many outdoor silhouettes are made at dawn and sunset. When doing this, take a low camera position and pose your subject against the sky or on a slight rise to obtain the necessary elevation. Make sure the sun is beyond or behind the subject, but do not permit direct rays of the sun to reach the lens. Frequently, especially

when the sun is low, you may have your subject directly between the camera and the sun, thus shading the lens.

For a silhouette, you will be photographing only the outline of your subject, which should be in full profile, either front, side, or rear. Elements of action may be added. The photograph on page HW 291 of a horse and rider etched against the ocean is an excellent example of a pictorial silhouette.

To illustrate how much the exposure must be cut down for silhouettes, a normal exposure for this scene would have been 1/25 second at f/8, but for the silhouette the shot was made at 1/100 second at f/22. Had the background been land, the proper stop would have been f/16 at 1/100 second. This picture is a good silhouette because it includes foreground reflection, which adds depth and draws attention to the center of interest. The swish of the tail and the raised foreleg add action. Back lighting gives form to the ripples on the water.

There are countless subjects which make good silhouettes. Have you ever noticed cattle standing on the crest of a hill, or a pretty girl leaning against a tree? Or trees alone, etched against the sky? All make excellent silhouettes. Sunrises are usually too brilliant to permit direct photography, but subjects accompanied by a dusky rose sky and clouds aflame with yellow fire offer dramatic picture opportunities. Pose your subjects directly against the sky, or against a sparkling background of water such as a river or lake. Remember, too, that if you can look directly into the sun without glare, so can your camera. At such times, try shooting directly into the light.

Although you may be accustomed to thinking of silhouettes in terms of outdoor photography, you can take effective pictures of this type indoors against a sheet or a brilliantly lighted wall. Crisp black silhouettes against white backgrounds will

serve a variety of purposes in home movies and also make stills worthy of inclusion in your album.

For example, let's say your young son has acquired a new bat and ball. He will be eager to show them off. Stretch a white sheet smoothly across a hall archway and at a distance of 8' from the opposite side place twin reflector lamps facing the sheet. Pose the boy 2' in front of the sheet in a batting stance, hanging the ball from a thin white thread. Remember that he is to be on the camera side of the sheet.

Proper exposure for this picture depends upon the speed of the film you are using. If you wish, take a light-meter reading on the sheet, and expose for that bright area. With No. 1 photofloods or strong household lights in reflectors, the stop on a movie camera will vary from f/5.6 for comparatively slow films to f/8 for fast films.

A similar result can be achieved if you place two flood bulbs in cardboard reflectors and direct their light against a white wall. Be sure to keep the rest of the room as dark

as possible. Pose the subject in front of the bright spot on the wall as you would against the sun or sky outdoors. Snapshots of excellent quality may be made in this way at 1/25 second with the lens stopped to f/16.

All sorts of interesting compositions and poses may be arranged. Your small daughter can pour tea for a friend, or read to her doll from a book. Try pasting cardboard cut-outs of the moon and stars, or storybook characters and animals, on the sheet. As a party suggestion, why not photograph the guests against the sheet with cut-outs representing the season, such as popping champagne bottles and corks for New Year's Eve, or turkeys for Thanksgiving? Both you and your guests will get much pleasure from such pictures, made either as stills or home movies.

Silhouettes also present an effective means of introducing your characters in a home movie. Suppose you wish to present, "A Typical Day at the Jones Home." Who are the Joneses? Dad, in profile, pipe in mouth; little sister, doll in arm; brother, full face to accentuate his big ears; and mother, hair fluffed, profile or full face.

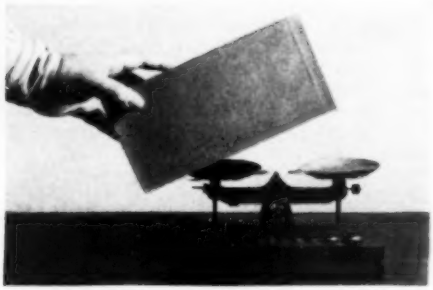
As an interesting alternative to still silhouettes in home movies, try photographing the shadows of people against a wall. This offers the advantage of allowing your subjects to move around, thus giving action to the scenes.

Combinations of silhouettes and shadows will add zip to a movie, especially if you wish to develop a threatening, dramatic sequence. Place your subject at one edge of the lighted wall about 4′ from the camera, and have a shadow from an assailant, or perhaps only a hand holding a gun, cast upon the wall from 10′ away. By this means, your audience sees virtually two actors as your character reacts to a threat represented by the shadow.

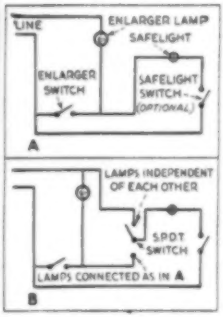
Similarly, to introduce a comedy character such as a gossipy neighbor, open the movie scene with a profile silhouette through a window shade. Your audience sees it as a window profile framing two lips moving rapidly. Suddenly the shade flies up and the face appears, well lighted, chattering like a magpie. You'll need a little help doing this. As the shade moves up while you are taking the picture, have an assistant snap off the silhouetting light and turn on front lights. This must be done at just the right moment so that there will be no noticeable change in the lighting either before or after the face appears.

These suggestions will give you other ideas for interesting and dramatic effects that can be added to your pictures. Remember, however, that silhouettes may be overdone, especially in movies. Being underexposed, they produce effective photography, but shadows tend to become theatrical. In still photography each picture stands alone on its own merits; in movies, the use of silhouettes and shadows should be related to the picture as a whole. In both fields, silhouettes offer many interesting opportunities, and they are fun to make.

A RUBBER SUCTION CUP attached to a photographic thermometer by a rubber band will hold the thermometer upright in a tray so that it can be read easily. In mounting the thermometer this way, cut away a little of the shank of the suction cup so as to expose the thermometer bulb to the solution in the tray. This will make possible a true reading.—HARRY RADZINSKY.



DARKROOM SCALES should always be protected from dust and moisture, as these may cause friction or corrode the delicate mechanism. A simple safeguard is to place a cardboard box over the scales, as shown in the photo above. Be sure that the box is large enough so that it will not come in contact with the mechanism.—LOUIS HOCHMAN.



ENLARGER SWITCH CONTROLS SAFELIGHT AUTOMATICALLY

IN FOCUSING an enlarger, it is easier to obtain a bright image on the easel if the safelight is turned off. The wiring diagram *A* at the left shows how an enlarger lamp and safelight may be connected together so that the latter will go out automatically when the enlarger is switched on. A 100- or 150-watt enlarger bulb will pass enough current to energize the safelight without emitting light itself. When one switch is closed, the enlarger bulb lights and the safelight goes out. A second optional switch is for turning off the safelight at other times.

The diagram *B* at the left shows connections for both automatic and independent control. Two switches are connected as in *A*, but a double-throw switch allows the safelight to burn independently.

EXPOSURES WITH HOME LAMPS

[*PHOTOGRAPHY*]

BECAUSE the supply of flash and flood lamps for civilian uses is much curtailed, the following exposure table for taking indoor pictures with ordinary home-lighting bulbs will prove useful. Many photographic results are superior when less light and longer exposures are used.

This exposure table is based on the use of extra fast panchromatic films and white-lined cardboard reflectors. The next larger lens opening should be used for films of medium speed, and the second larger opening, or four times the exposure, for slow films. Box cameras should be considered as having a lens stop of f/16.

If the walls of the room are a dark color, use one lens opening larger. The smaller of the two lamps should be used as a camera light pointed directly at the subject, the larger lamp being used as a side light placed at 45 deg. to the camera axis, and 2′ higher. Both lamps should be the same distance from the subject.

Distance of lamps to subject in feet	Lens Opening	Exposures in Seconds: One 60-watt One 100-watt	Exposures in Seconds: One 100-watt One 200-watt
3½	f/4.5	1/10	1/25
	f/6.3	1/5	1/25
	f/8	1/5	1/10
	f/11	1/2	1/5
	f/16	1	1/2
5	f/4.5	1/5	1/10
	f/6.3	1/5	1/10
	f/8	1/2	1/5
	f/11	1	1/2
	f/16	2	1
8	f/4.5	1/2	1/5
	f/6.3	1	1/5
	f/8	1	1/2
	f/11	2	1
	f/16	4	2

POPULAR SCIENCE MONTHLY SHOP DATA

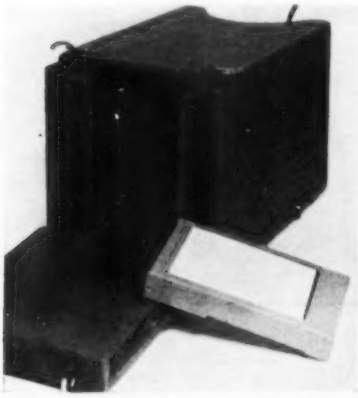
SIMPLIFIED UNIT MAKES IDENTIFICATION PHOTOS

THE wartime need for identification photos prompted the building of this simplified unit, which can readily be operated even by persons unfamiliar with photography.

A cabinet containing a fixed camera and brackets supporting two No. 1 flood lamps and reflectors is fastened to a wall. The height of the camera above the floor is the average height of a person's face.

Two brackets with ordinary half-round reflectors were cut down from regular drafting-table lamps. Although the reflectors are adjustable as to position and direction, they are set properly once and then merely swung into and out of the cabinet without changing the adjustment. To give better lighting, one lamp is above eye level and one below, the lower reflector being screened with white tracing cloth. A buff roller shade is pulled down from the ceiling behind the subject.

This photographic unit is so arranged and adjusted that any personnel employee can take good pictures



Film packs are used because exposed films can be removed separately for convenience

The fixed camera is a wooden box built for a 10.5 cm., f/4.5 lens and shutter taken from an old 2¼" by 3¼" camera. Film packs are used so that any exposed negatives can be removed one at a time for developing and printing without wasting film. Small 1⅝" by 2½" packs are used, as the rather long and narrow shape compensates for the varying heights of subjects.

Before the lens board of the camera box was fastened in place, a ground glass was inserted where the film pack fits and the camera focused for the size of image desired. With the camera illustrated, the distance from lens to film is 5", and the distance from lens to subject is 53". The lens board was then fastened in the camera box, and the camera held in place on a shelf in the cabinet with short dowels. The lens is stopped at f/9, and the shutter set at 1/25 second.

Such a camera is inexpensive to build, and the use of a lens with a comparatively long focus eliminates the "fattening" effect so common in close-ups made with the average small camera. The back of the camera opens on hinges to release the film pack. All of the joints must fit tightly so as to prevent any light leaks, and the camera should be painted black inside. The dimensions of the camera box will be governed by the size of the film pack used and the thickness of the stock used in making the box. As shown in the accompanying photographs, the front of the top is cut away to accommodate the shutter-setting dial and cable release.—WILLARD ALLPHIN.

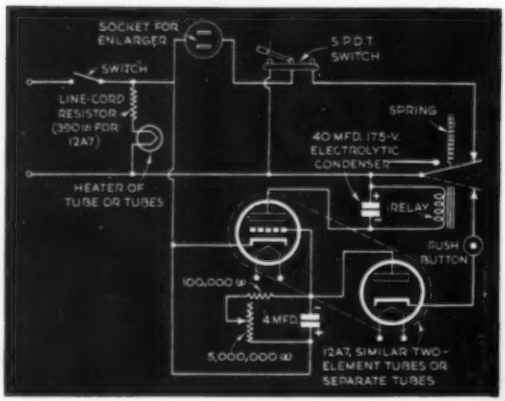
ELECTRONIC PHOTO TIMER

YOU'LL find in the radio-parts junk box most of the material you need to build this useful interval timer. It can be set to shut off a printing or enlarging lamp after exposures of from 2 to 56 seconds, and all subsequent exposures at the same setting will be uniform. For longer exposures, the original interval can be repeated by pushing the button again. The circuit will work with almost any two tubes, or with any one of a variety of twin-element tubes. Tubes no longer fit for radio use will do provided the filaments are good.

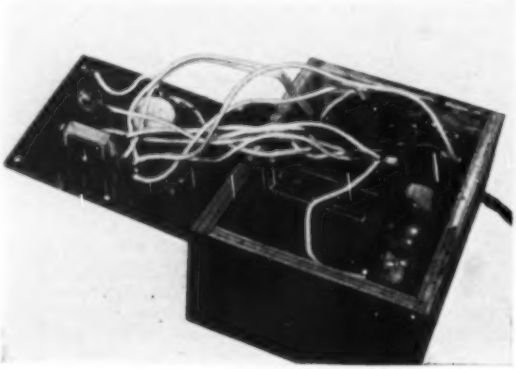
Much as a sand glass keeps track of time by allowing sand to trickle from a reservoir through a tiny opening, so this electronic timer allows electrons to trickle from a reservoir (a condenser) through a tiny opening (a high resistance). A 4-mfd. condenser is charged by the rectifier unit when the push button is pressed, and the charge leaks out slowly through a variable resistor across the condenser.

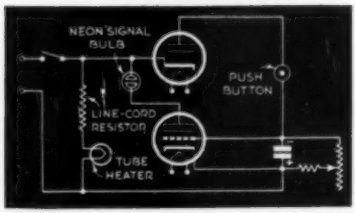
As long as the condenser is charged, it puts its full negative potential of about 150 volts on the grid of the amplifier. This heavy negative bias on the grid blocks the plate current in the tube completely, and the relay opens, closing the upper contact that turns on the enlarger or other device. As the charge on the condenser gradually drains off through the variable resistance, the volt-

By JOHN W. CAMPBELL, JR.



Above is a diagram of the wiring hookup. Be sure to use a suitable line-cord resistor. Below, an inside view of the timer is shown





The circuit above, requiring no relay, gives a visual signal. A neon-glow bulb goes out when the button is pressed and lights again when the set time is up

Built from Old Radio Parts

age falls and eventually drops below the cut-off bias of the tube. The tube becomes conductive once more, and the relay is energized, opening the enlarger circuit.

The essential parts are a rectifier tube, any type of grid-controlled tube, a high-quality bank of paper condensers, a high variable resistor of the volume-control type, a push button, and a relay.

Paper condensers from the power pack of an old-type receiver are by far the best. Electrolytic condensers will not do, as they cannot hold a charge more than a few seconds. The condensers are the critical parts of the system.

The original timer shown used a 4-mfd. paper condenser, a 5-megohm variable resistance, and a 12A7 tube. A 100,000-ohm protective resistance in series with the variable resistance prevents it from short-circuiting the condensers and rectifier when set at zero, and makes the minimum time about 1¼ seconds.

The 12A7 tube is not the best for the purpose. It takes 13 volts grid bias to cut off the plate current in that tube; therefore, when the condensers fall to 13 volts, the relay closes. A tube that cuts off the plate current at 3 volts would give a time interval of about 80 seconds with the same resistance and condensers. A 6J7 or 6SJ7 tube would serve nicely as the grid-controlled element.

The 40-mfd. electrolytic condenser across the relay delays the opening of the latter long enough after the button is pressed to permit the paper condensers to reach full charge, and, in addition, prevents relay chatter.

If a pentode-type, grid-controlled tube is used, it is simply connected as a triode, with its screen grid connected to its plate. The rectifier tube can be any type—for example, a pentode with control grid tied to cathode and screen grid tied to plate will serve. A single twin-unit tube can be used *provided the two units in the tube have separate cathodes.*

An old audio transformer can be converted into an efficient, heavy-duty relay for use with this rig. Simply unbolt the core pieces and rearrange them to make an E-shaped, 3-pole electromagnet. This can be done with some cores merely by lifting off one section; those composed entirely of E-shaped laminations are converted by reversing half of these to match the other half.

Use only the primary winding of the transformer. The armature is fitted with contact points from an old buzzer, phone jack, or some similar device. A spring normally lifts it off the magnet. The double-throw switch shown enables one to turn on the enlarger as long as desired for focusing.

WINDING HEATING ELEMENTS [*ELECTRICAL*]

Electric heating elements are usually made from coiled nickel-chromium resistance wire. The following table gives the necessary data for winding the wire on arbors of various sizes.

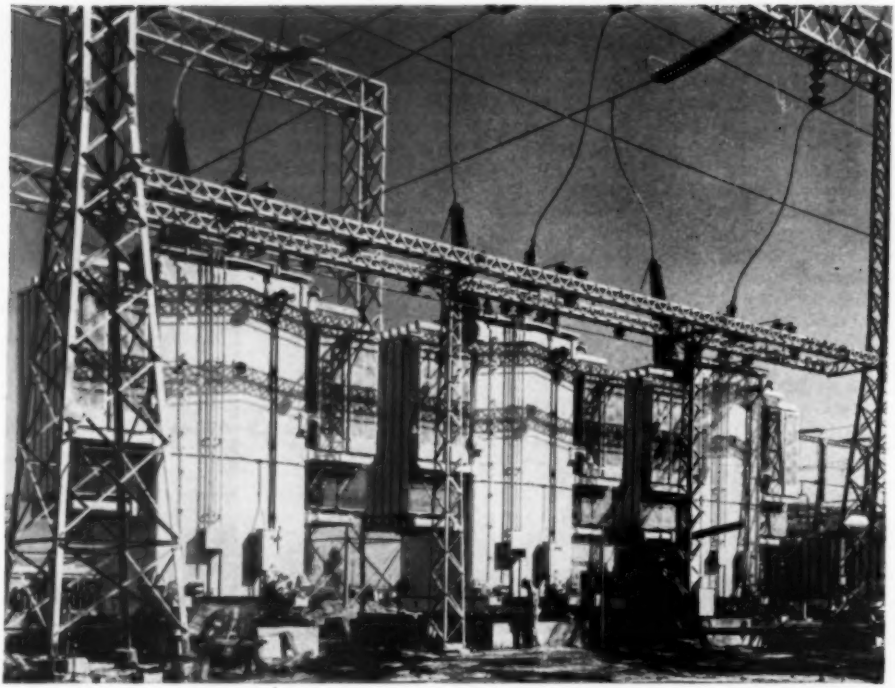
PER INCH OF CLOSE-WOUND COIL

	3/32" arbor		1/8" arbor		3/16" arbor		¼" arbor	
B. & S. Ga.	Feet	Ohms	Feet	Ohms	Feet	Ohms	Feet	Ohms
16	.77	.19	.94	.23	1.29	.32	1.56	.39
17	.83	.26	1.02	.33	1.43	.46	1.76	.56
18	.90	.36	1.11	.45	1.56	.63	2.00	.81
19	.97	.47	1.21	.61	1.72	.86	2.22	1.11
20	1.06	.67	1.33	.84	1.91	1.21	2.50	1.59
21	1.15	.93	1.46	1.17	2.11	1.69	2.80	2.44
22	1.27	1.29	1.62	1.65	2.36	2.40	3.16	3.21
23	1.40	1.78	1.78	2.27	2.65	3.37	3.53	4.50
24	1.55	2.49	2.00	3.22	3.00	4.83	3.61	6.35
25	1.72	3.50	2.22	4.50	3.30	6.70	4.48	9.10
26	1.91	4.92	2.48	6.38	3.71	9.54	5.00	12.85
27	2.13	6.88	2.75	8.88	4.17	13.45	5.66	18.30
28	2.38	9.75	3.12	12.80	4.55	18.63	6.53	26.70

TO USE this table, measure the space available for the coiled wire and estimate the desired wattage. From a table that gives the length and size of resistance wire for the wattage desired, select the size best suited, using the middle size wherever possible. Coiled wire may be stretched from 1½ to 4 times closed coil length. If the space will take a longer coil than the middle size, try using the next size wire.

Example: a 750-watt element with space 37" long is to be wound on a ⅛" arbor. You will find that sizes from No. 18 to No. 22 could be used. The middle size is No. 20, which takes 23.6' of straight wire. Divide 23.6 by 1.33, which results in 17.7' of close-coiled wire. The element space is 37" long, so it would be stretched a little over twice its length, which is satisfactory.

POPULAR SCIENCE MONTHLY SHOP DATA



Giant transformers like these are used for stepping up voltage in long-distance transmission of power

HOW ELECTRONS WORK

FIRST STEPS IN ELECTRONICS

By CHARLES I. HELLMAN

WHEN it was once learned that magnetism could be produced with electricity, scientists strove to do the converse—that is, to produce electricity with magnetism. Michael Faraday successfully performed the first experiments that generated an induced current, which we today know as a flow of electrons. This Faraday experiment is shown in Fig. 1.

A coil of wire containing many turns is connected to a galvanometer. When a bar magnet is thrust into the coil, the galvanometer needle swings aside, indicating that an electric current has been produced in the coil. When the magnet is withdrawn, the needle swings to the opposite side, showing that a current of opposite direction has been produced, or that the current has been reversed. This process of producing an electric current—of setting electrons in motion—by means of a varying magnetic field is called *electromagnetic induction.*

It is possible to increase induced voltage by using a coil with more turns, by strengthening the magnetic field, by moving the magnet faster, or by a combination of the three. In the huge dynamos that generate A.C. from the motive power supplied by water wheels or steam turbines, there are coils with many hundreds of turns, extremely powerful electromagnets, and a high relative speed between the two.

Another tremendously important application of the principles of induction is found in transformers, which are an integral part of power-supply systems. A transformer, shown in simplified form in Fig. 2 and in cross section in Fig. 3, consists of two separate coils—the primary and the secondary—wound on an iron core. When A.C. is sent through the primary, a magnetic field is set up. This magnetic field, varying in both intensity and direction, travels through the core and into the secondary coil, inducing a voltage in it. The process of inducing

a voltage from one circuit to another is called *mutual induction.*

One of the greatest advantages of a transformer is its ability to step A.C. voltage up or down by the use of the proper ratio of turns on the primary and secondary coils. If the secondary has more turns than the primary, the induced voltage in the secondary will be greater than that applied to the primary, and vice versa.

A transformer is not limited to two windings. It may have, for instance, a primary and a number of secondaries. Such types are used in radios to furnish both high voltage for the operation of vacuum-tube plate circuits and low voltage to heat the tube filaments.

Electrical power is most efficiently transmitted over long distances if it is kept at high voltage and low current. The output of the dynamo at the generator station is stepped up by transformers to meet these transmission requirements and stepped down again for application at the receiving end.

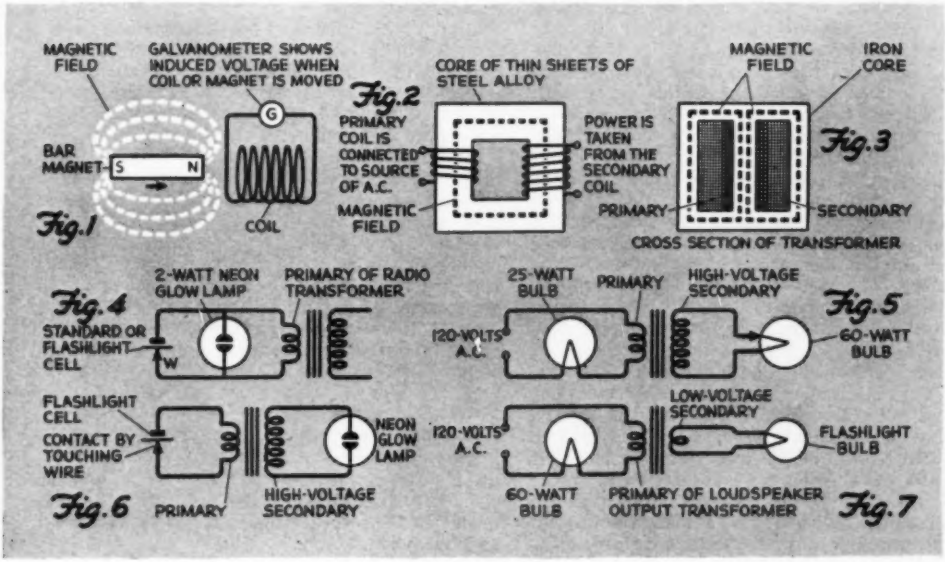
Self-induction, occurring when a varying flow of electrons is sent through a coil, is defined as the cutting of a wire by the lines of force flowing through it. When the wire is cut by this expanding magnetic field, a momentary electromotive force (E.M.F.) opposed to the applied one is induced. If the flow through the wire is stopped, the magnetic field collapses, again cutting the wire, but this time in the opposite direction. When a changing electronic flow in a coil causes changing magnetism in the core, this latter in turn induces a flow of electrons in the coil itself. As long as the flow in the coil increases, the lines of magnetic force increase, and electron movement set up in the coil will be in opposition to that producing the magnetism.

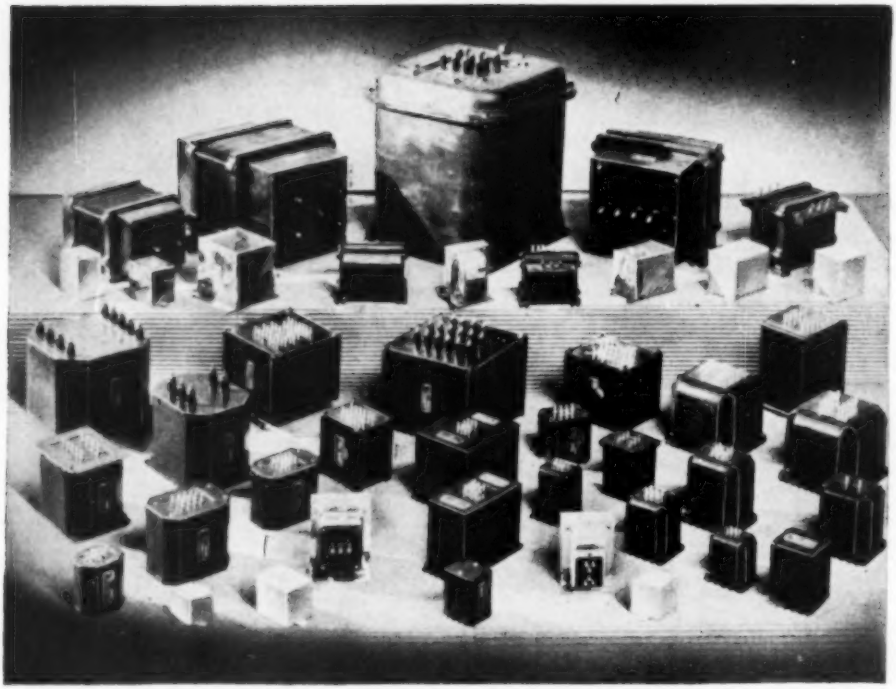
Since the counter electromotive force (C.E.M.F.) of self-induction opposes any change in the flow passing through a coil, inductance produces an effect that is the electrical equivalent of *inertia.* Just as the inertia of an automobile becomes most apparent when an attempt is made to start or stop, so electrical inertia shows its presence when an electronic flow is varied in intensity.

The reaction of a coil against the increase in the flow of electrons through it is known as *inductive reactance.* Coils that have as their main function reaction against these changes are called choke coils.

Self-inductance shows itself by the presence of an induced voltage due to a varying current, and the unit of self-inductance, known as the henry, has been defined as the value of inductance that produces an induced E.M.F. of 1 volt when the current through it varies uniformly at the rate of 1 amp. per second. Since some devices, espe-

WITHIN WIRE COILS





These are just some of the many forms of iron-core transformers and chokes used in electronic devices

cially in radio, have small inductance values, the millihenry, or 0.001 henry, and the microhenry, or 0.000001 henry, are frequently employed.

A 2-watt neon bulb shows the intensity of the E.M.F. of self-induction in an interesting experiment. Plug the bulb into a 120-volt lighting socket, and it will glow normally. Connect it across an ordinary dry cell, and it will not glow at all. This shows that the bulb requires a voltage considerably above the 1.5 volts delivered by the dry cell.

Now place the bulb in the circuit shown in Fig. 4. Connect the wire *W* to the dry cell; then remove it suddenly. One plate of the neon bulb will glow momentarily, indicating the application of a high voltage. This voltage is produced by the sudden drop of the electronic flow through the primary of the transformer. The resulting decrease of the magnetic field through the coil produces a high E.M.F. of self-induction.

That the transformer transfers power, but does not create it, is shown by the experiment in Fig. 5. A 25-watt lamp is used to indicate how much primary current flows. It glows dimly when no load is applied to the secondary. When a 60-watt bulb is placed across the secondary as a load, the bulb in the primary circuit glows brightly, indicating that the primary is drawing more power in order to supply the output.

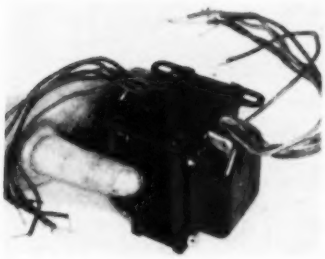
To show mutual induction, connect a neon bulb to the high-voltage secondary of a receiver transformer as in Fig. 6. If the connection of the primary to the dry cell is broken quickly, the neon bulb will flash, and it will do so whenever this primary circuit is broken. Electrical power is transferred by mutual induction from the primary to the secondary and is stepped up in the process.

An output transformer that may be obtained from an old receiver can be used as a step-down transformer. The primary leads are connected to the 120-volt A.C. leads through the 60-watt bulb (Fig. 7). The secondary output is about 2 volts and may be used when a low A.C. voltage is needed at approximately 1 amp. The exact voltage may be found by using an A.C. voltmeter, or by trying several flashlight bulbs of different voltages. Try all the bulbs, starting with the one of the highest voltage. If a 2.5-volt bulb, for example, glows brightly, the output voltage is about 2.5 volts.

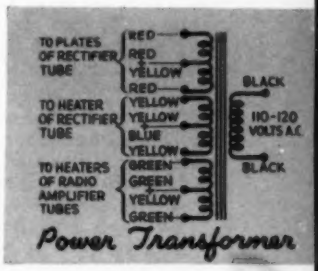
This little transformer is useful for operating buzzers, lighting flashlight bulbs, and the like. The 60-watt bulb is a protective device in case the transformer is defective or improperly wired.

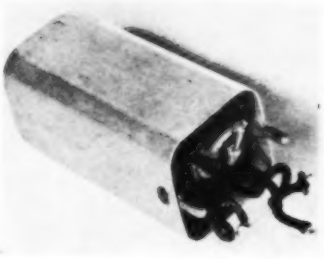
Servicing Your Radio

LEADS on replacement transformers, color-coded in much the way that condensers and resistors are coded, save about 50 percent of the soldering time required for parts furnished only with lugs. Below are some of the colors usually found on the leads of power, I.F., output, and audio transformers. All manufacturers do not adhere to a standard form of color code for their products, however, so it is advisable to check the part first with an ohmmeter to make sure that the color code has been used.

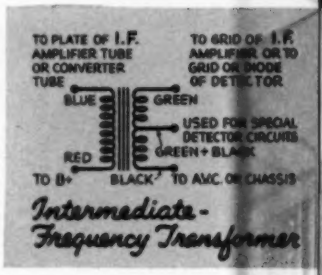


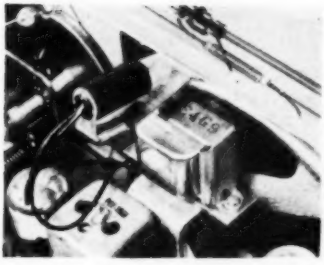
POWER TRANSFORMERS have at least 11 leads. On the standard 110-120 volt type, the primary winding has two black leads; the tapped secondary to the rectifier-tube plates, two red and one red-yellow; the tapped secondary to the rectifier-tube heater, two yellow, one yellow-blue; and to the amplifier-tube heaters, two green and one green-yellow. The two-tone leads are the taps.



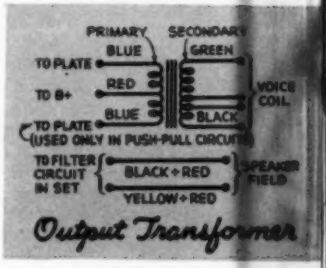


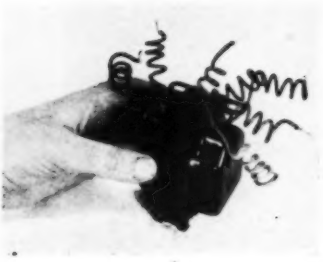
I.F. TRANSFORMERS are simpler. The primary winding has a blue lead connecting to the tube plate and a red to the B+, while from the secondary a green lead connects to either the grid or diode of the following tube and the black to either the A.V.C. or ground. Where there is a tapped secondary winding, such as in a detector stage employing full-wave diodes, the lead is usually green-black.



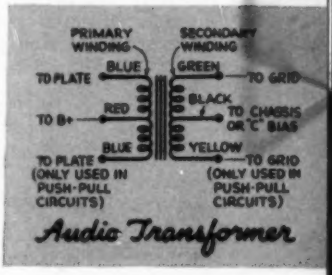


OUTPUT TRANSFORMERS have a blue lead from the primary to the power-tube plate and a red to the B+ of the power-output tube, while for push-pull there is an extra blue lead to the plate of the other output tube used. The secondary to an electrodynamic-speaker voice coil has two or more leads, and the code varies, but the two leads from the speaker field are usually black-red and yellow-red.

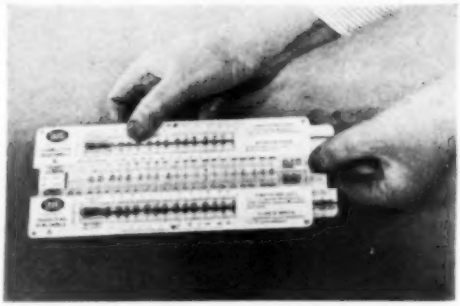




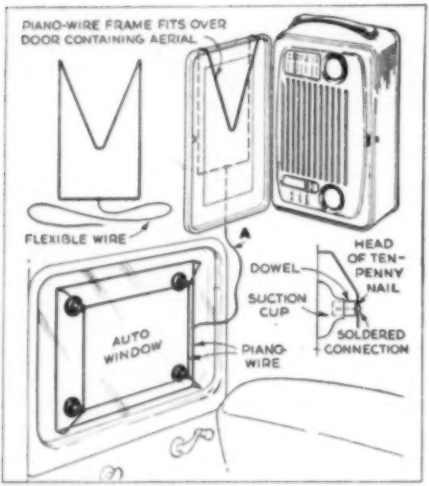
AUDIO TRANSFORMERS are color-coded almost universally. A blue lead connects the primary to the plate of the preceding audio amplifier or detector tube and a red to the B+, while a green lead connects the secondary to the grid and a black to either the "C" bias or chassis. If there is a push-pull tube, a second blue lead connects to its plate and a yellow on the secondary connects to its grid.



radio ideas

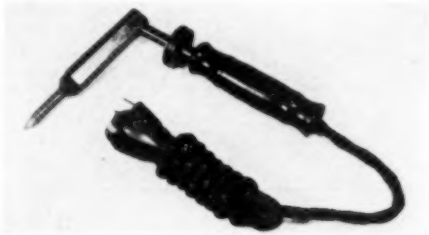


THIS RADIO SLIDE RULE may be used to solve problems in reactance calculations and is accurate within 2 percent. It enables electronics engineers to calculate in one setting of the slide resonance frequency, capacitive and inductive resistance, dissipation factor, and coil "Q."

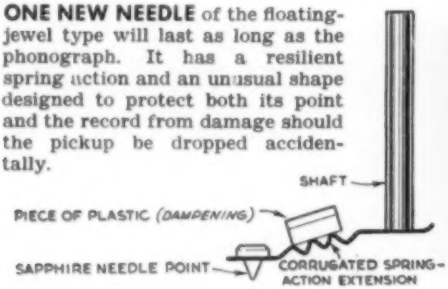


AN AUXILIARY AERIAL can be built with suction cups to fasten on an auto window for better reception on an ordinary portable used inside a car. Two frames are made of piano wire. One, acting as a condenser, is hooked over the door containing the built-in portable aerial. The other is attached to the car window. Connecting wire *A* to a ground improves selection when the radio is used in the house.—LARRY RUFFNER, JR.

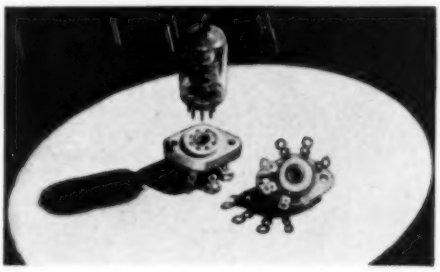
A HATCHET SOLDERING IRON is said to give better balance and to be less tiring for the operator on many soldering operations. Incorporating all the features of plug-tip irons, it has in addition a special device in the shaft which keeps the handle cool even when the iron is used for long periods at a time. These irons are available in sizes of 80, 100, 150, 175, and 200 watts. Each comes complete with a metal stand, and all elements are replaceable.



ONE NEW NEEDLE of the floating-jewel type will last as long as the phonograph. It has a resilient spring action and an unusual shape designed to protect both its point and the record from damage should the pickup be dropped accidentally.



MINIATURE CERAMIC SOCKETS have been developed for use on ultrahigh frequencies with the 9000 series of miniature tubes and the 1S4 type. The sockets have contact points of heavily silver-plated phosphor bronze and are self-aligning so that they receive the tiny prongs without danger of fracturing the glass base of a tube when it is being inserted. The contacts can be oriented for minimum capacity effect.



A. C. Motor Develops Full Torque at All Speeds

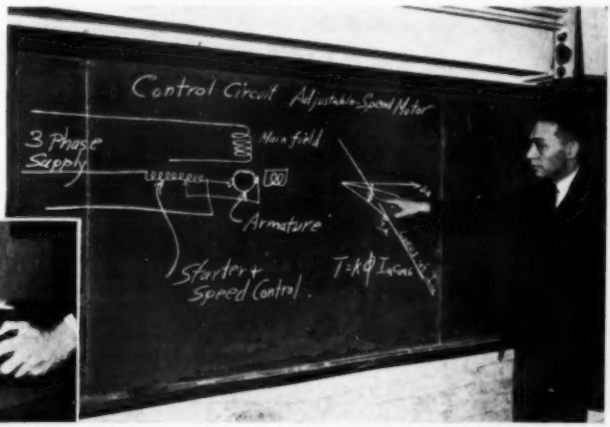
STEP pulleys and gear reductions may be largely eliminated from the machine shop and factory of tomorrow, thanks to an adjustable-speed A.C. motor developed by Prof. A. G. Conrad, S. D. Smith, and P. F. Ordung, of Yale University. This revolutionary motor, perfected after three years of research, affords a wide choice of speeds with practically constant torque—something hitherto possible only by combining an A.C. motor, a D.C. generator, a D.C. motor, and an exciter in a complicated and costly hookup unsuitable for general use.

With the new motor, which is powered from three-phase A.C. lines, a knob that can be operated with one hand provides complete speed control from a standstill to the maximum speed for which the motor is designed. The same control can be used to reverse the motor or to obtain a braking action to quickly reduce the speed of the machinery driven. In the latter case the motor acts as a generator due to a reversal of the power component of the armature current.

High starting torque makes it possible to accelerate heavy loads readily, yet the armature currents at starting are at low voltage. The input currents are therefore small and do not occasion line-voltage disturbances as conventional motors do. Applied to the home of tomorrow, this means that lights will not dim momentarily when the refrigerator or oil burner starts up.

Operators of lathes, drill presses, and other machine tools powered by this type of motor will be able to obtain many speeds without shifting belts or gear-drive levers. As torque is constant, plenty of power will be available at all times for drilling and similar operations to be done at low speed.

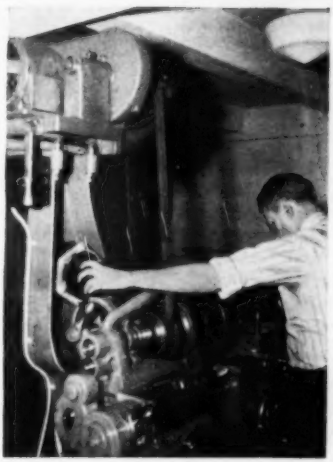
The new control produces an unbalance of line currents that makes its application to very large motors undesirable, but this does not apply in the case of small motors.



Left above, experimental motor and control unit. At the right above, Prof. Conrad explains vector diagram of the new motor. Note compensating winding set at 90 electrical degrees to field winding

The control unit can readily be mounted independently of the motor and within easy reach of the operator, as shown on the drill press at the left

In conjunction with step pulleys, a tremendous speed range is possible. The autotransformer control involves no energy loss such as resistors do



Coaxing New Life out of the Old Sewing Machine

By BENJAMIN NIELSEN

RESCUED from attic and basement, long unused and even obsolete sewing machines can be put back into service by thrifty wives and mothers who wish to make and repair family clothing to help along the budget or because of real and threatened scarcities. Grandmother's gilt-decorated relic, as well as machines of more nearly contemporary make, can be renovated so as to do excellent work. Cleaning and readjustment are all that many such old machines need.

The first step, regardless of the model, is to clean and oil the machine thoroughly. Remove the thread, bobbin, and shuttle. Take off the plate through which the feed points project and the large vertical plate above it after removing the screws that hold them. If there is a plate on the back near the handwheel, remove it also. Using an oil can, squirt a generous amount of gasoline in each oil hole and on all movable parts and joints.

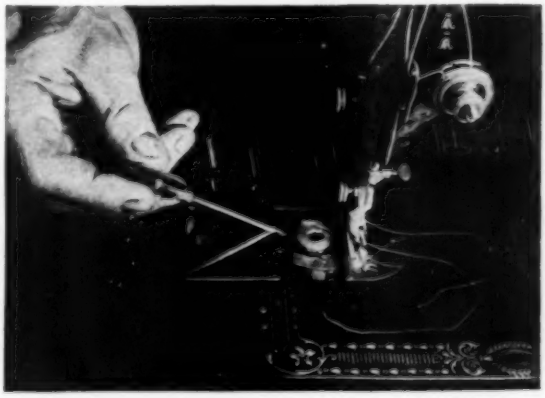
Next, tilt the head back, arrange a drip pan such as a shallow baking pan underneath, and wash the machine thoroughly with a brush dipped in gasoline. *Be extremely careful, for gasoline is inflammable and explosive.* Never use gasoline near an open fire, nor in a room that does not have ample ventilation.

Follow the cleaning of the head with thorough washing of the handwheel, bobbin winder, and mechanism in the left side; then brush gasoline on the treadle and large belt wheel. Remove any thread or lint that may have collected around the wheel shaft or pitman rod connecting the wheel and treadle.

Under the front shuttle slide there is usually a little well filled with wool waste. From this well a very small hole runs to the shuttle race in the case of a vibrator (long-shuttle) machine. When this wool is saturated with oil, just enough works through to lubricate the shuttle. Take the wool out and clean the hole with a pin; then wash the wool in gasoline and replace it or use new wool.

Most oscillator-type machines have a split piece of felt that rubs on the shuttle race. This felt should be cleaned, oiled, and adjusted, if necessary, so that it rubs both sides of the shuttle. It is good practice to clean and oil it occasionally when the machine is in use. Many machines with ro-

Adjust tension of the lower thread by tightening or loosening the screw that holds the flat tension spring on the shuttle



tary shuttles—the third common type manufactured—have an oil hole in the shuttle race. This should be oiled frequently.

Before doing any oiling, however, run the machine for a few minutes, wipe all the parts dry with a clean cloth, and wait an hour to allow all traces of gasoline to evaporate. If it is more convenient, kerosene may be used instead of gasoline, but in this event 24 hours should elapse between cleaning and oiling. Use only a good grade of sewing-machine oil and drop it in every oil hole and on every friction surface.

Unnecessary play can be taken up in most joints by turning an adjustment screw. Make only one adjustment at a time. If it does not correct the trouble, return it to the original position before trying another. Run the machine after each slight adjustment to avoid passing the proper setting.

Correct adjustment of both upper and lower tension, as shown in the photographs, is the determining factor of a proper stitch, one in which both threads are precisely at the same tension and produce a line of stitching exactly the same on both sides of the material.

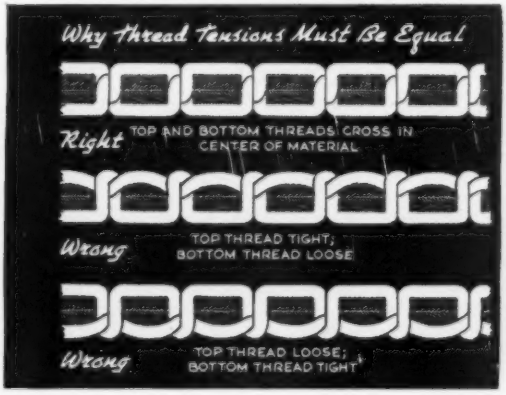
In testing the stitch, double a piece of material and sew across it for a few inches with thread of the correct size. Remove the piece from the machine, hold the stitch with about 1" of it between thumbs and forefingers, and pull steadily until there is a snap. If both threads are broken, the tension is even. If only the upper thread is broken, the upper tension is greater; if only the lower is broken, it is the lower tension that is greater. Either tighten or loosen one of the tension screws, depending on whether the stitch is loose or tight.

After cleaning and oiling, if the machine still runs hard, the belt may be too tight or too loose, or the bobbin winder may be running on the belt or wheel. Missed stitches may be caused by a bent or broken needle, one too fine for the thread, or one not suited to the machine itself. The needle also may be set too high or too low. On modern makes, it should be pushed up as far as it will go, but on older models it must be set so that the eye is 1/16" to ⅛" below the point of the shuttle when that point is nearest the needle.

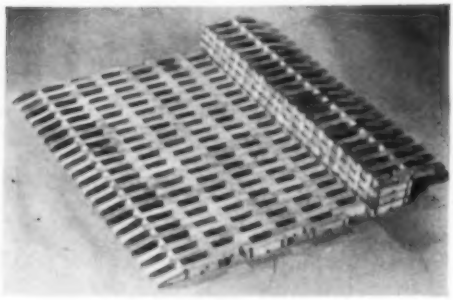
Stitches may be missed if the shuttle point is dull. It may be sharpened on a fine whetstone, but whet only the round side of the shuttle, not the flat side. A shuttle that has a broken point will have to be replaced. Dirt lodged under the tension spring or between the tension plates may cause looped stitches on one side of the material.

Breaking of the upper thread may indicate incorrect threading, or the needle may be turned wrong in the machine. If the lower thread breaks, the shuttle or bobbin case may be threaded improperly, or the thread may be wound unevenly on the bobbin. Bending the thread guide in the direction of least winding on the bobbin will correct the last. A rough needle hole in the throat plate may also cause thread to break. Smooth the hole with a small reamer.

If stitches "pile up" because the material is not advanced regularly, make sure the presser-foot pressure is great enough to hold the cloth against the feed teeth. These teeth may be too low, but on most machines they can be raised by turning an adjustment screw. They should rise about 1/32" above the plate. If the teeth are dull from wear, they may be sharpened with a stone or file.


Why Thread Tensions Must Be Equal
Right
TOP AND BOTTOM THREADS CROSS IN CENTER OF MATERIAL
Wrong
TOP THREAD TIGHT; BOTTOM THREAD LOOSE
Wrong
TOP THREAD LOOSE; BOTTOM THREAD TIGHT

The upper thread must have the same tension as the lower to insure proper stitching on all materials

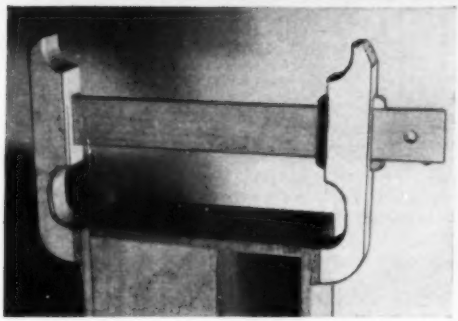


FRONT-DOOR MATS constructed of hardwood links fixed on wooden dowels have been developed to take the place of rubber ones. Beveled ends reduce the danger of tripping, and the mats can be folded or rolled into a compact package when they are to be stored. The wood is easily kept clean, for soap and water will not harm it. Mats are 1″ in thickness, but come in various lengths and widths from 18″ by 32″ to 30″ by 44″.

INSULATION RETAINERS made of gypsum, wood, or metal have been devised to hold insulation firmly in place. The strips are 24″ by 1¼″ and fit diagonally between studs spaced 16″ on centers, overlapping the horizontal joints of house insulation. In many cases the retainers may solve the problem of holding insulation permanently in place. They have notches in each end for nailing into studding.

PAPER SANDBAGS like that at the left, if dropped on a nonexplosive incendiary bomb from a height of 3′ or more, will burst and smother it under a layer of sand. The bags are sealed against moisture and will withstand ordinary handling without breaking.

PUTTY IN TAPE FORM comes in handy rolls for home repair jobs. It will not dry out, crack, or otherwise deteriorate in storage. To fix rattling windows, as at right, cut the strip to the required length, lay it over the old putty, and press down firmly. When it dries to a dark gray it may be painted.



GLUE CLAMPS that have no threads or other turning parts are said to have a grip of almost 100 lbs., and will hold glued work up to 12" in size. They are made of smoothly finished hardwood, with cork pads to prevent work from being marred. The sliding member has a hole slightly larger than the bar and is fitted with two friction shoes which exert a wedging action when pressure is applied at the ends of the jaws.

PLASTIC SPRAY PUMPS which can be used for spraying small plants, flowers, and the like have been developed. The spray solution is contained in an ordinary Mason jar, and the pump part fits on the threads of the glass. It is easily manipulated and carried from place to place, and can be used to great advantage in all small spraying jobs where a great deal of coverage is not needed.

A WINDOW LUBRICANT that will not stain anything with which it comes in contact is shown at the right. It can be applied with a brush to either wood or metal surfaces. All rust should be removed from metal surfaces before the fluid is used.

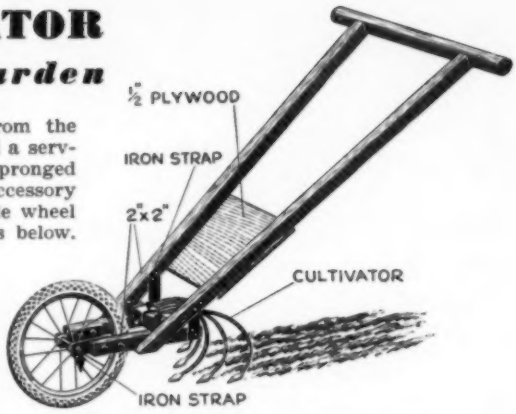
PAPER CAULKING GUNS now take the place of metal types. The one shown at the left works on the principle of the old-time bellows. After the plug at the top is released, the bellows end is pressed and the caulking material dispensed in much the same way that toothpaste is squeezed from a tube. The gun comes already loaded.

WHEEL CULTIVATOR

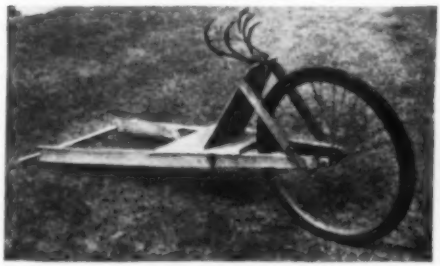
for Your Victory Garden

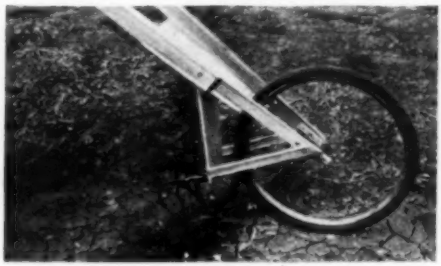
WHEEL cultivators are disappearing from the market, but the Victory gardener can build a serviceable one from simple materials. The five-pronged tool can either be bought as a wheel-hoe accessory or taken from a hand cultivator. A bicycle wheel was used for the implement in the photos below. Panels of ½" plywood join the frame members and support the tool rigidly.

A smaller wheel, such as one from a discarded tricycle, should be used in the alternative design shown in the drawing. This has the advantage that force is applied in a direct line to the cultivator prongs. Assemble all parts with bolts and nuts. Strap-iron extensions support the axle. Two braces make a rigid unit of the handle members and the lower frame.



Dimensions depend on the size of the wheel, but the handle should come to about elbow height. Use bolts and nuts throughout in assembling the parts





Searchlight for Model Boat Is Made from Flashlight Bulb

TO MAKE this model searchlight, obtain a 2-cell, pen flashlight bulb and with a small soldering iron melt the two drops of solder on the side and bottom of the base. Wipe off the melted solder and free the two wires. Next, cut away the shell with a triangular file or a jeweler's saw (Fig. 1) and carefully chip away the cement underneath. Solder a 6" length of copper wire to each of the two wires protruding from the bulb as in Fig. 2. Insulate them with several coats of shellac; then bring them both to one side of the bulb as shown in Fig. 3. Coat the entire bulb, except for the magnifying tip, with aluminum paint. Mold plastic composition wood over it, let dry, and sand to shape.—N. P. GUIDRY.

Fig. 1

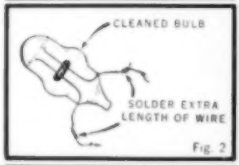


Fig. 2

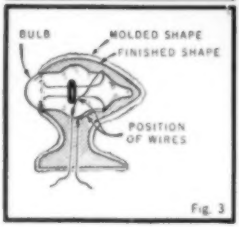
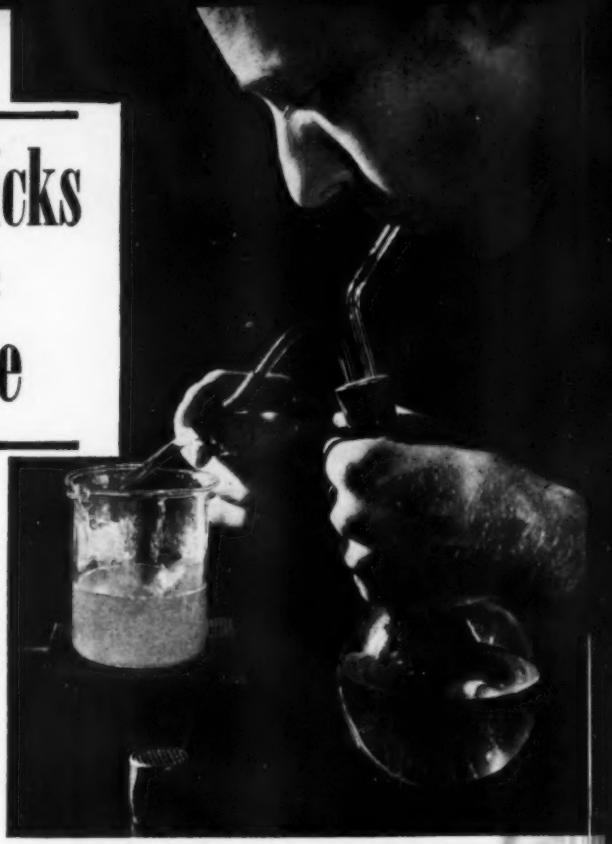


Fig. 3

Above, the realistic searchlight is shown compared to a cigarette. The lead wires should be well inside so they will not be exposed when the molded shape is sanded down. Use one or two pen flashlight cells, depending upon the light desired

Professional Tricks
WILL BETTER YOUR
Lab Technique



Good equipment is essential in the home lab. One of the necessities is a wash bottle, which you can easily make

THERE is almost no limit to the number of experiments which may be performed in the home lab with simple equipment and only a limited number of operations. If you familiarize yourself thoroughly with the use of your equipment and master the best technique for carrying out various operations, your hobby becomes simpler, more enjoyable, and more scientifically valuable.

Once you learn how to handle chemicals properly, the results of experiments become more conclusive, and dangerous accidents are less likely to occur. The following hints are fundamental to *all* laboratory practice, and should be kept well in mind when working out any experiments in the home lab.

To begin with, the chemical laboratory must be kept scrupulously clean. A tiny speck of foreign chemical in a bottle of tested-purity reagent may spoil a test. A few grains of chemicals mixed in error may cause an explosion. For these reasons, never return excess chemicals to a reagent bottle. Either save the chemicals for another experiment or throw them away. Small quantities of dry reagent may be removed from a bottle with a clean spatula or a strip of paper folded to form a scoop. Never lay glass stoppers on a table where they might become contaminated, but place them in a clean glass or porcelain dish.

When weighing chemicals, never place them directly on the scale pans. Use a creased square of white paper, balancing this with a similar piece. Have a supply of these on hand and throw the papers away as they are used.

On precision scales, weights should always be handled with forceps to prevent possible contamination or corrosion of them by substances from the fingers.

Observe those caution signs on bottles of chemicals! Keep bottles containing acids or ammonia away from your face when opening them. Bottles marked *POISON* should be handled with special care, and should be kept away from the mouth and skin. Wash your hands repeatedly while using poisons, and carefully clean up any spilled chemicals with rags that can be thrown away. If these precautions are observed you need not fear to use poisons. As a further safeguard, keep a list of antidotes in a prominent place in the lab.

A few chemicals require extra special handling. Yellow phosphorus, for example, must be kept under water, as it catches fire spontaneously in the air. Never touch this chemical with your fingers. You may be seriously burned. To cut a piece for use, remove a stick of it from its bottle with tongs and place it immediately in a dish filled with water. While still holding it with the tongs, cut pieces off the other end with a sharp knife. Be sure all phosphorus used for an experiment is either burned or returned to the bottle. Pieces left lying about may cause a fire.

(CONTINUED)

Above are inexpensive devices for handling hot beakers, test tubes, crucibles, and the like. Ordinary hot-food tongs also are useful for these purposes

Beakers and flasks should be one third full if the contents are to be boiled to dryness. Keep them covered with a watch glass so as to avoid dangerous spattering

Certain chemicals must be handled with great care. Yellow phosphorus is one. Never carry it except with tongs, and always cut it under water as shown below

Sodium and potassium metals must be handled with similar care. However, these must be kept under kerosene, as water causes them to decompose violently and liberate hydrogen, which often catches fire from the heat of the reaction. Cut these in a dish under kerosene. Scrape off any coating of oxide and dip the pieces in some ether to remove the kerosene. Never throw waste sodium or potassium down a drain, as the reaction with water might cause a serious explosion. When reacting or cutting these metals, it is best to wear goggles to protect your eyes from possible spattering.

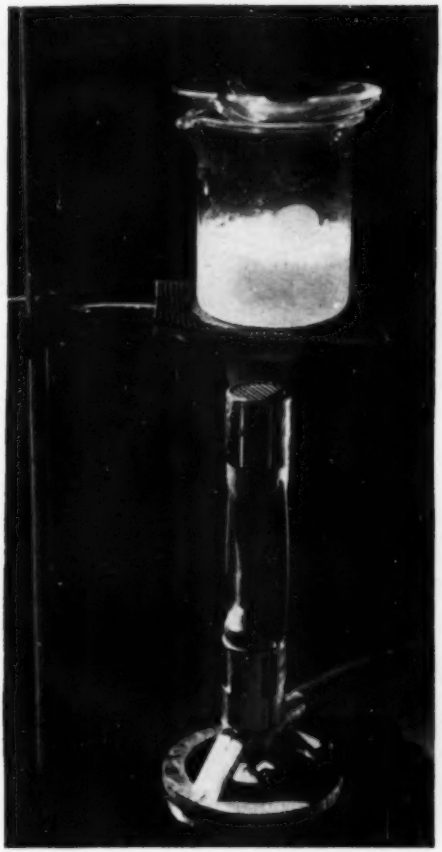
That *KEEP FROM FLAME* warning found on certain containers means you must keep them at least *twenty feet* from any exposed flame—especially when opening them. The vapors of some inflammable liquids travel far and fast. Even if they do not carry a flame back to the bottle, they may form an explosive mixture with the air.

Few experiments are performed in the home lab without the assistance of flasks, beakers, or test tubes. Be sure that all of these are sound and of good glass. For heating or reacting small quantities of chemicals, test tubes are ideal. They may be supported by a regular clamp on a ring stand, or by a wire holder in the hand. All test tubes should be heated gradually. For heating dry chemicals, or for the destructive distillation of coal, wood, and the like, use heat-resistant test tubes.

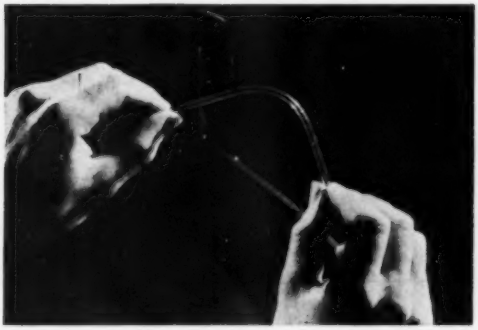
Beakers should be used for heating large quantities of chemicals. Always protect these from direct flame by means of a square of gauze with an asbestos center. When heating or boiling a liquid for a very short period, a beaker may be filled about three quarters full. For boiling a solution away to dryness, however, fill the beaker only one third full and cover it with a watch glass to prevent loss from spattering.

Florence flasks are the type generally used for boiling or distilling. Liquids are less likely to superheat or "bump" in the round-bottomed flasks than in the flat-bottomed type. A gauze square should be used under these also.

A pair of tongs such as used in the kitchen for lifting hot foods makes an excel-



Strong, neat bends in glass tubing are easily made. Above, a wing top is used on the Bunsen burner in order to spread the flame, and the tube is twirled so that it will heat evenly all around. When the flame turns yellow, remove the tubing and, holding the two ends, gently shape to the proper curvature



lent device for handling hot beakers. Crucibles can be handled safely with flat tongs having tips bent almost to a right angle.

Filtering is a laboratory operation which can be speeded and improved if proper attention is paid to details. Filter paper should be of a size which, when folded, does not reach quite to the top of the funnel. The long point at the end of the funnel should touch the receiving beaker near its top. This arrangement permits the continuous flow of the filtrate down the side of the beaker without splashing.

Before pouring in the solution to be filtered, wet the sides of the filter with a stream of water from the wash bottle; then press the paper to the sides of the funnel.

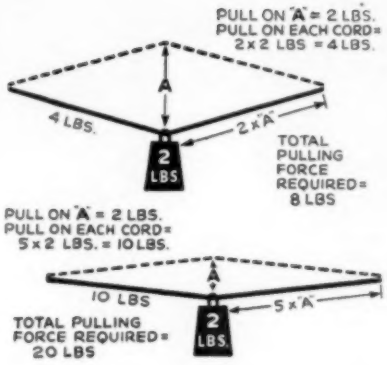
Hold a glass rod across the top of the pouring beaker and allow the liquid gently to strike the side of the filter paper about one fourth of the way down from the top. This glass-rod arrangement is useful whenever liquids are poured from beakers. If the beaker has no lip, the edge should be lightly greased with petroleum jelly to prevent the liquid from running down the side.

Every home laboratory should have at least one wash bottle. Water from its nozzle can be used to wash down solid matter from the inside of beakers and test tubes, to moisten filters, to rinse the inside of glassware, and for many other chores.

A wash bottle may be easily made from a 500-ml. Florence flask, a two-hole stopper, and three pieces of bent glass tubing. The nozzle may be drawn from a piece of tubing.

To make perfectly round bends without kinks, a sufficient length of glass tubing is first heated as shown in the photo above. Use a wing tip on your Bunsen burner to spread the flame. Hold the tube loosely and rotate it slowly to heat it evenly on all sides. Remove the tube from the burner when the flame turns yellow. Then, holding the ends with your fingers, shape it gently to the proper curvature.

home EXPERIMENTS


PULL ON "A" = 2 LBS.
PULL ON EACH CORD =
2 x 2 LBS = 4 LBS.
A
4 LBS.
2 x A
2 LBS
TOTAL PULLING FORCE REQUIRED = 8 LBS
PULL ON "A" = 2 LBS.
PULL ON EACH CORD =
5 x 2 LBS. = 10 LBS.
A
10 LBS
5 x A
2 LBS.
TOTAL PULLING FORCE REQUIRED = 20 LBS

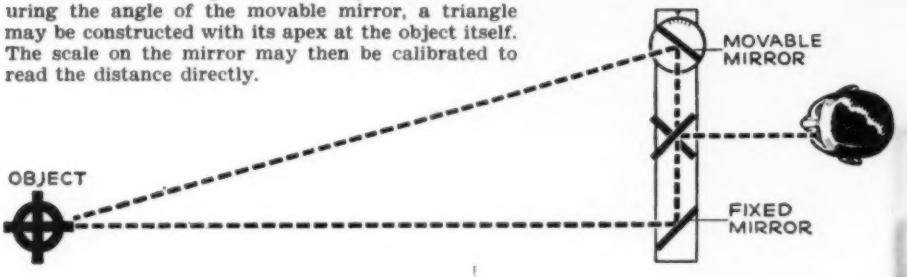
WEIGHT PUZZLER. Suspend a 2-lb. weight from the center of a stout cord about 2′ long. Now pull on the ends of the rope and you will find that you cannot straighten the cord. The explanation is not as puzzling as one might think. The more nearly horizontal the cord becomes, the more the forces exerted by the hands pull against each other, and the harder it is to lift the weight. By constructing a parallelogram, as shown in the drawing, it is possible to measure directly the forces required to lift a weight to any position. To find the pull on each cord, divide the length of the cord by that of the diagonal *A* of the parallelogram; then multiply the weight of the quotient so obtained, as shown in the two examples above.

FOUR SIMPLE SCIENCE STUNTS

WHY ARE GEARS NECESSARY? Tie a piece of twine to a flatiron, or some similar weight, and fasten the other end to the edge of a disk of wood about 1″ in diameter mounted tightly on a pencil. Now try to twist the pencil in order to wind up the twine and thus move the iron. You will find you cannot budge it. The disk corresponds to high gear. If you take the twine from the disk and wrap it around the pencil instead, you will find the iron will move easily. The pencil, with its smaller diameter, corresponds to low gear.

HEAVY CARS ride over uneven roads more comfortably than light cars because of inertia. The heavier the body, the greater is this inertia. A simple setup will demonstrate the effects of this. Suspend a little bucket from an improvised spring. The bucket represents the body of your car and the spring represents an ordinary auto spring. Tap the upper turn of the spring, and the bucket will respond quickly by vibrating greatly. If you weight the bucket and repeat the experiment, it will respond much more slowly, due to the added weight and the consequent increase in inertia. The vibration will not only be smoother, but the bucket will come to rest more quickly.

AN OPTICAL RANGE FINDER which illustrates the principle of elaborate military ones can be made from a stick and several mirrors arranged as shown. The fixed mirror on the left-hand side is placed at a 45-deg. angle. In the center of the base, two small viewing mirrors are mounted, one having its face parallel to the left-hand mirror and the other fixed at right angles directly below it. The mirror on the right-hand end of the base is mounted so it revolves on a calibrating scale below it. Placing one eye so that it can see part of the object in the upper viewing mirror and part in the lower one, rotate the right-hand mirror until the two images coincide. By measuring the angle of the movable mirror, a triangle may be constructed with its apex at the object itself. The scale on the mirror may then be calibrated to read the distance directly.



SHOW WHY YOUR AUTOMOBILE ACTS AS IT DOES

YOUR CAR MUFFLER is a metal cylinder through which sharp puffs of exploded gases are bent around circuitous paths in a stream so steady that it is almost silent. A model muffler can be built from a cardboard tube and five or six cardboard disks perforated and arranged as shown. Whistle through the tube before the disks are in place—the sounds go through clearly. Arrange the disks and try again. This time the sounds you make will be almost inaudible.

CAR BRAKES should be checked frequently. What happens when one brake responds more quickly or with greater force than the other may be demonstrated with a toy car. Wind some string around the axle of the left wheel so that it retards the turning of the wheel, and let the car roll down an incline. Because of the unequal speed of the wheels, the car will slide into a definite skid. On a real car the reaction would be just the same and much more dangerous.

How to Design Piers and Abutments for Your Model Railroad

by David Marshall

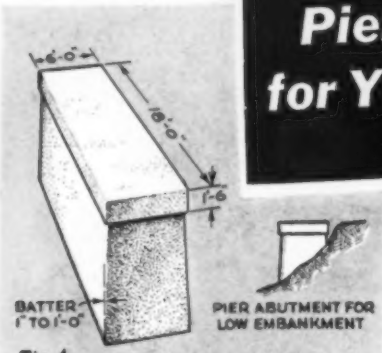


Fig. 1 *Pier Abutment* (FOR DOUBLE-TRACK LINE)

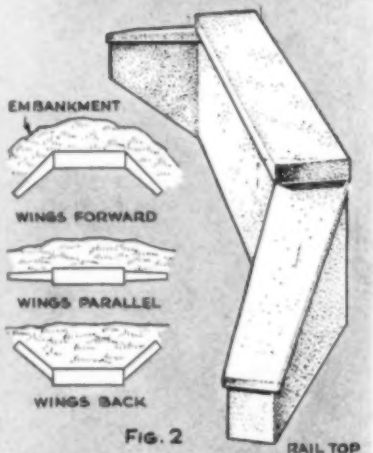


Fig. 2

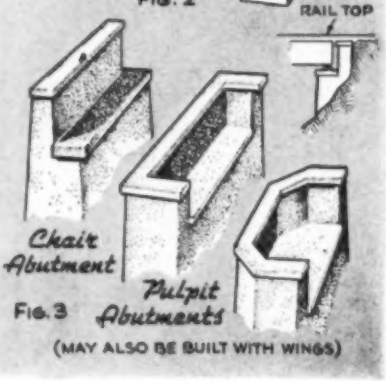


Fig. 3 (MAY ALSO BE BUILT WITH WINGS)

WHEN we speak of a steel bridge, we don't really mean what we say, for only part of a bridge at most is ever made of steel. This is the upper portion, or superstructure. Below it is the substructure of masonry or concrete to which the steelwork is anchored and upon which it rides. This substructure consists of two abutments and usually one or more piers.

Piers and abutments, therefore, form the seats upon which the superstructure is erected. Steel slide or roller chairs are anchored to their broad upper surfaces, and upon these chairs the immense weight of the steel span rides with a certain freedom of movement.

To anyone who understands their function, such chairs are as interesting as the span itself. Indeed, if they are carefully modeled, they will enhance the effect of well-built piers and abutments beyond all proportion to their size.

ABUTMENTS AND PIERS. An abutment is a substructural unit that supports one end of a steel span or superstructure. It differs from a pier in that it is normally of somewhat heavier construction because it must serve not only as a pier but also as a retaining wall. Usually the approach to a railway bridge is along an embankment, or fill, which must be retained where it ends abruptly at the bridge abutment.

To a large extent this additional function of the abutment explains its many forms. Thus, if the embankment is low, or if the approach is along a trestle, we use a simple pier abutment (Fig. 1). If the embankment is high, we require a winged abutment (Fig. 2), which is structurally no more than a pier abutment with two retaining walls, or ramps. These always follow the slope of the embankment and may or may not lie in the same plane as the abutment.

Chair abutments and pulpit abutments are usually employed with deck-type bridges. The seats of these abutments must lie well below the grade level and, to prevent the embankment from encroaching upon the seat, the abutment is extended upward to grade level along the embankment side of the seat and occasionally also around the ends of the seat. The former type is a chair, the latter a pulpit abutment. In both cases, the seat becomes a kind

of step in the abutment as shown in Fig. 3.

A pier is usually lighter than an abutment because it meets only one strain instead of two—the downward thrust of the superstructure and not both that and the lateral thrust of embanked earth. Piers are employed, however, only if the bridge is one of the type that is composed of more than one span.

RULES OF SPACING. In the field of railway bridge building, American practice is characterized by the types most easily erected. Plate girders are favored for spans up to 50′ and rivet trusses for those from 50′ to 75′. For viaducts, that is, for bridges of more than one span, girders are preferred. Pin trusses are indicated for all spans of more than 75′, but rivet-truss bridges, with certain exceptions, are the largest the average American model railroader can find space for building.

Any succession of piers must be built at center-to-center intervals of not more than 50 scale feet for girders and 75 scale feet for rivet trusses. Since experienced railroad engineers say that nothing is gained by shortening girder spans, but that everything is gained by keeping the trusses as short as possible, the rule for model builders is to keep trusses as short as possible and to space the piers for girders at as near a maximum of 50 scale feet (12½ inches in 0 gauge) as equal intervals will permit.

CONCRETE COLOR. Railway abutments and piers are made of brick, stone, or concrete, but we build them all of wood. The concrete specimens are weather-streaked plain surfaces and perhaps a little smudged. But clean or dirty, all concrete jobs are of a distinctive color, so if your model work is to be convincing, it must be painted accurately.

Use nothing but flat colors, never a glossy paint or an enamel. To find your concrete color, begin with a flat white and add a little yellow ocher and a little black. The proportions are difficult to prescribe, but you can't go wrong if you take your colors and a sample piece of wood outdoors on a day when the sun is not too bright. Set your sample against a piece of real concrete and continue mixing paint until an effective match has been achieved. You may have to mix the paint several times—but your patience will be rewarded if, at the end, the color is correct and realistic.

STONE AND BRICKWORK. For model stone masonry, there are several points to be observed. The blocks used in a stone retaining wall are 48″ long and 15″ high. The same size blocks are also used for the lower courses of stone abutments and piers, except where surfaces are curved. As the courses rise, the stones are shallower. For the upper courses, half stones of 10″ by 24″ are usual. Stones are often dressed for retaining walls at stations, but at other locations the faces that are exposed to view are rough.

Dressed stones in a single plane are easily imitated. Lay out the horizontal courses and staggered vertical joints on a piece of white pine, using a hard pencil; then scribe them into the wood. An excellent scribing tool can be made of a nut pick sharpened by filing. With a steel ruler as a guide, run the sharpened pick along each penciled line, cutting deeply into the wood. To produce the effect of V-joints, widen the cuts by forcing a blunt pick along them, being careful not to employ too much pressure.

Rough stones are made of ¼″ whitewood cut into strips to represent each course of stones. Bevel the strips along both edges to simulate horizontal joints. To make vertical joints, scratch the strips deeply with one corner of a file at regular intervals. Next scoop small bits out of the face of each stone with a pocket knife. Finally, glue and tack the strips in place on a surface of 1″ pine. All kinds of stones, from wedges and keystones to panels and buttresses, can be made in this way.

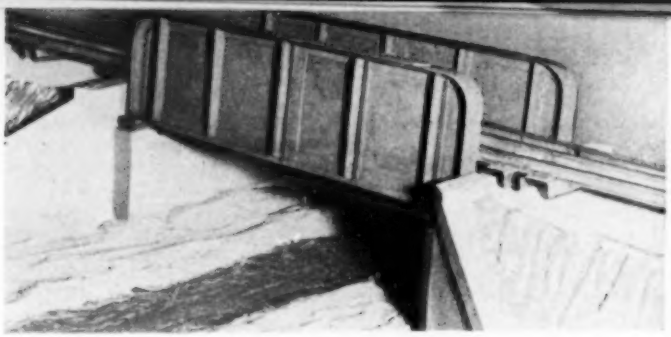
Paint stone masonry a dirty white, getting the paint well into every chink and crack. Then brush on a granite color lightly, covering all stone faces but missing most of the scribed lines. The effect of this will be the dirty white showing through as mortar. Granite color can be achieved by using gray paint as a base and adding raw umber and a touch of blue.

Successful brickwork is achieved by lightly scribing the horizontal lines on wood and painting a dull and soot-blackened brown. The staggered vertical lines are omitted.

Much of the success in building model-railway scenery depends upon details of piers and abutments

Cardboard, scraps of wood, and cement are all you need to make this realistic bridge

By
JOHN J.
GALLIVAN



Model Girder Bridge Can Be Built for a Few Cents

A MODEL through-girder bridge that will be realistic and surprisingly strong can be made of 1/16" thick glossy cardboard and thin wood such as can be bought at model-airplane supply houses. Full-size dimensions are given in the drawing, but these may easily be scaled down for an O-gauge, OO, or HO system.

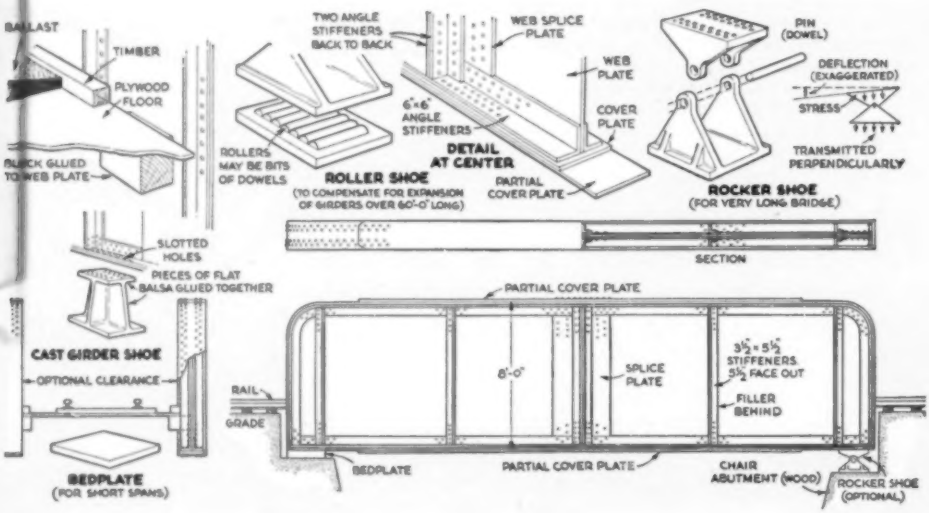
Cut the web plates to shape first. These can be cut to any length up to about 75' scale size. Plates longer than 30' should have two or more splice plates instead of one. Glue on the splice plates and also the flat sides of the angle stiffeners all around the perimeter of the two web plates. Next, cut cardboard filler strips to go under the flat sides of the vertical angle stiffeners, and glue wooden faces to the sides after these are in place.

A strip of cardboard equal in width to the distance between the outstanding faces of the stiffeners on both sides is glued around the perimeter of the entire web. This strip forms the outstanding face of the perimeter angle stiffeners.

Rivet heads may be cleverly simulated with a typewriter. Set the machine for stenciling and, using stiff, glossy paper, strike the keys with enough pressure to make sharp impressions on the opposite side of the paper without cutting through it. Glue strips of the indented paper to the perimeter angle stiffeners, splice plates, and cover plates, all of which have a double row of alternately spaced rivet markings. The vertical angle stiffeners have one row of single-spaced rivets.

The entire bridge is next given a coat of diluted shellac, followed by black, green, or orange show-card paint.

A piece of plywood extended to rest on the abutments and supported on strips attached to the girders makes a satisfactory floor. Girder footings vary in type according to span lengths. For very long spans, use rocker shoes and set one of these on a roller shoe. The drawing shows two types of shoes supporting one span in order to illustrate both footings, but in practice the shoes would be of the same type.



Longer Wear *from* Metalware

By KENNETH M. SWEZEY

ONE way of contributing to the war effort is to take scrupulous care of home metalware that is still too useful to be turned in to the scrap drive. By learning the characteristics of different metals, and by applying this knowledge, you can prolong the life and preserve the beauty of objects made from them, thereby freeing men and materials that might otherwise be needed to make replacement goods.

Aluminum utensils should never be cleaned with alkaline solutions such as washing soda or trisodium phosphate, since these will darken and pit the metal. A bland soap is usually sufficient to keep aluminum ware gleaming, with the occasional use of very fine steel wool to remove stains.

You have probably noticed that when you cook certain foods in aluminum pots, the pots become darkened and discolored. This is because such foods contain soluble salts of metals, such as iron. The aluminum combines with these salts, freeing the metal they contain, which is deposited on the inside of the pot. Instead of trying to scour it off, simply cook some acid food, such as rhubarb, tomatoes, or the like, in the same pot —and behold—the mineral matter will be completely recovered in the form of valuable food elements, and your pot will be bright as a dollar again!

Tinware is really made of iron or steel,

coated very thinly with tin for protection. If this coating is subjected to careless treatment, it will break off, and the pan will rust. Such utensils should never be scoured. If you wish to remove burnt food, boil water containing baking soda or washing soda in the pan for a few minutes.

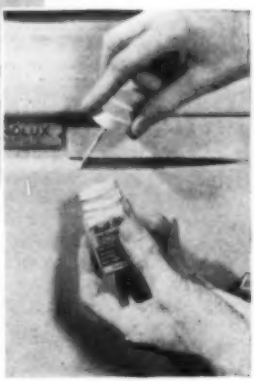
Enameled pots and pans should be treated as carefully as your choicest glassware, since the enamel coating is a close relative of glass. Sudden heating or cooling will cause the enamel to crack, and any sharp knocks will chip it.

Grease can be removed from iron pans by washing them in hot soapy water, or in a solution of washing soda and water. Since iron rusts easily, the pans should be dried carefully. If you wish to store an iron pot, coat it with a saltless oil or fat, wrap it in paper, and put it away in a dry place.

Chromium-plated and nickel-plated articles may look alike, but they should not be treated alike. Chromium plating is highly resistant to tarnish, but it can be scratched very easily. It should never be cleaned with any type of scouring powder or metal polish—a soft damp cloth is sufficient to keep it in its original bright condition. Nickel plating, on the other hand, tarnishes more easily than chromium plating, but it may be cleaned with any gritless metal cleaner.

Brass and copper pieces that have not been lacquered may be cleaned with a saturated solution of table salt in warm vinegar, or with lemon rind and salt, hot buttermilk, or hot tomato or rhubarb juice. Copper cooking utensils should always be kept scoured, since the brown oxide or green carbonate of copper that forms from tarnish reacts with the organic food acids to create undesirable salts.

Chipped places on refrigerators ought first to be cleaned with any good rust remover, as at left



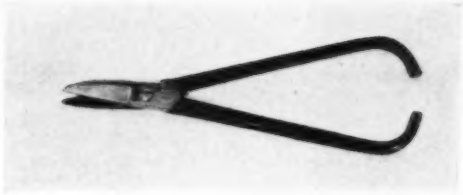
Right, the exposed metal is smoothed down with some emery paper, then coated with touch-up enamel

To remove sticking food, soak a utensil in soapy water and scrape with a wooden spoon

Nickel-plated ware can be safely polished with a gritless cleaner or whiting paste

Unlacquered brassware or copperware is made clean with a solution of salt and vinegar

Boiling washing soda and water in tinware about five minutes will remove burnt foods



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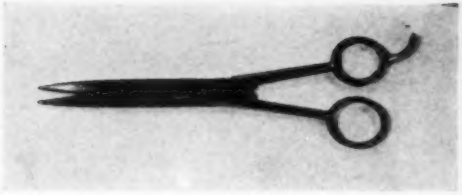

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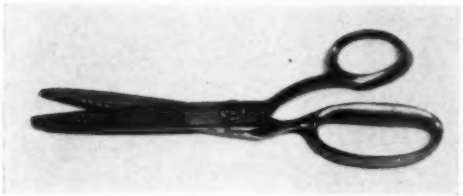

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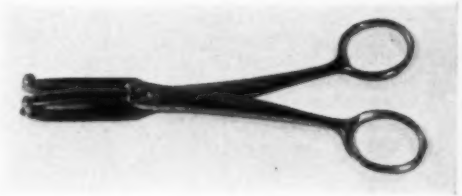

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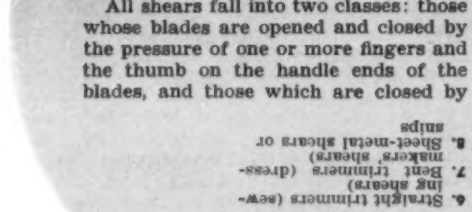
Question Bee

SHEARS as we know them probably date back to the sixteenth century or earlier, for they were apparently used by the Venetians.

All shears fall into two classes: those whose blades are opened and closed by the pressure of one or more fingers and the thumb on the handle ends of the blades, and those which are closed by the hand, but opened by a coil spring between the blades or by spring action of the handle itself. Common scissors are an example of the former class; pruning and grass-trimming shears are examples of the latter. Can you name those shown here? Write down your answers; then turn the page upside down to see how correct you are.

ANSWERS

1. Jewelers' shears or snips
2. Barbers' shears
3. Pinking shears
4. Flower shears
5. Embroidery scissors
6. Straight trimmers (sewing shears)
7. Bent trimmers (dressmakers' shears)
8. Sheet-metal shears or snips



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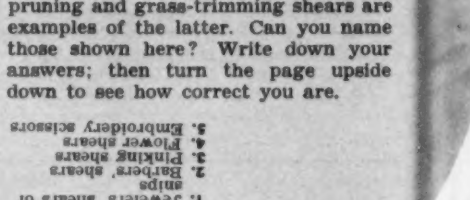

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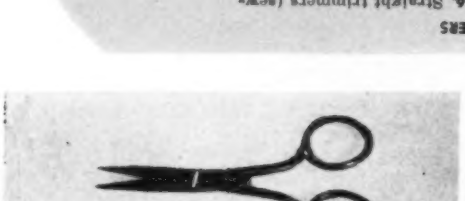

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"Smoke" Armor

(Continued from page 62)

with gas masks. Research into screening smokes fitted into their thought and experimentation. Dr. Langmuir approached the problem of a smoke screen from the purely scientific viewpoint of obscuring physical objects by obstructing or diverting all rays of light by which they could be seen.

He concluded that the effectiveness of any smoke must depend on the size, density, and color of the smoke particles. He concentrated on the ideal particle size. Having arrived in his mind at that ideal size, he turned the job of producing it over to his assistant, Mr. Schaefer, who built a big "smoke box" on an upper floor of the General Electric Laboratory. Soon from that upper floor there poured out such smoke that once the factory fire department came rushing to the scene to douse a nonexistent blaze.

Schaefer made five model devices before he found one which apparently turned out the proper smoke particle, a liquid globule of microscopic proportions. He could mount to the top of his smoke box after creation of a smoke screen within it, and look down upon that layer of cloud as an airman today looks down on the screens that are set up over American military targets by special smoke companies of the Chemical Warfare Service. He tested its obscuring power against various colors and shapes, with screens of varying thicknesses and heights.

Then the National Defense Research Committee brought in the Standard Oil Development Company's industrial production engineers to build a model unit for producing the Langmuir-Schaefer type of smoke screen in quantity. These engineers designed and produced within a month the first smoke-generator unit, working on the job of breaking down a special liquid compound into tiny particles of uniform size by use of steam.

The unit produced was an odd-looking contraption—as most of its successors are today, although new designs are now being made. On the back of the M-1 generator are three cubicle tanks, joined together to look like one big box. These carry sufficient smoke materials for long-time operation. In the middle of the contraption is a small gasoline motor, and at the front is a big cylindrical boiler, with a number of little vents on a horizontal pipe through which the smoke clouds are ejected. The whole thing looks a little like one of those horse-drawn fire engines of the gay nineties, once it is mounted, as it always is for mobility, upon a four-wheel trailer. It is just a machine for driving heated smoke compounds through spray nozzles.

Its designers called the first unit "Junior," in affectionate irony, to distinguish it from some other experimental smoke generators, then in the making. "Junior" was a military code word that now has lost all military significance.

On June 2, 1942, they trundled Junior up into the Schoharie Valley, a few miles away from the General Electric plant at Schenectady. On a cloudless, sunny morning, with only a light wind blowing, the producing scientists, industrial engineers, a collection of Army and Navy officers, and some representatives of the Canadian National Defense Research Council went out to see the machine in action. The onlookers climbed to the top of a steep cliff, about 600 feet high, from which they looked down at some miles of rolling farmlands and surrounding hills.

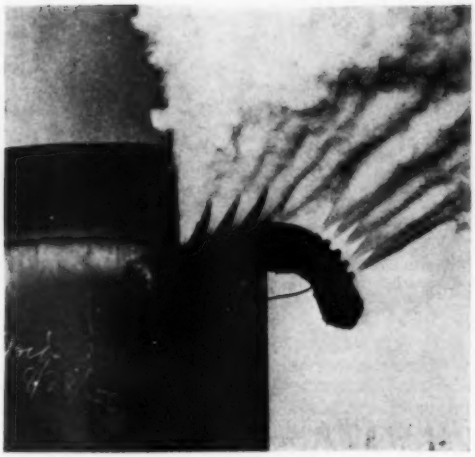
First they saw a few smokes emitted by some other generators. These were not impressive. Then "Junior" went to work. From his one big boiler there came rolling out a white mist which blotted from view several miles of the valley within a few minutes. Close to "Junior's" ten-lipped mouth this haze was a billowing, swirling smoke cloud —the kind of dense rolling smoke one might see in the burning of a great pile of autumn leaves, only whiter. As it spread out, however, it was the kind of fog one may see hanging low over swamps on misty mornings, obscuring all vegetation and wildlife.

Everybody who saw it knew they had what they were after. If one such contraption could blot out miles of field and highway, and render invisible all distinguishing marks of the countryside such as groves and farmhouses, a few dozen could blot out cities.

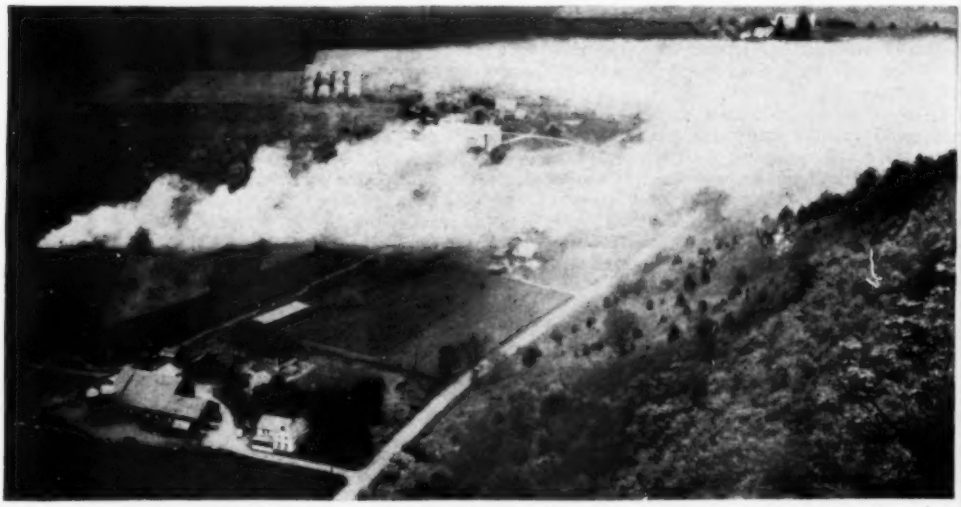
The machine was taken to Edgewood Arsenal, that center near Baltimore, Md., where the Chemical Warfare Service manufactures much of the nation's chemical-warfare equipment. It was tested again. Officers found that they could walk through the clouds of billowing fog without the discomfort that came from the old smoke pots. The haze that encircled them did not soil their clothing. It was an atmosphere in which they could continue to work. That artificial fog had an amazingly high persistency. In succeeding tests it was found to hang together for as much as 20 miles downwind, and to obscure all land for at least half the distance.

Contracts were let for the manufacture of these M-1 generators. As the machines rolled from the production lines, they were used in amphibious training operations on Cape Cod, Mass. Their white mist quite blanketed a shore line and stopped traffic on surrounding roads for miles. A group of the

Dr. Irving Langmuir, Nobel Prize winner who devised the formula for the artificial fog, with the first experimental model of the generator . . .



. . . which grew up to be the M-1. The principle of operation is to break down a special liquid compound into tiny particles of uniform size by means of steam

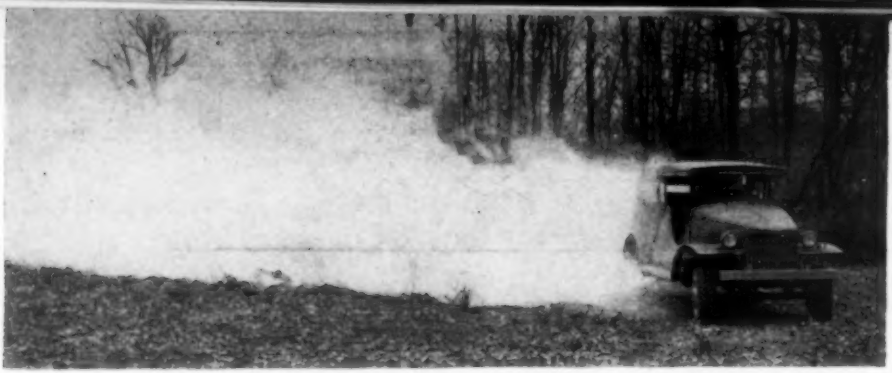


Farmhouses, roads, and other landmarks are blotted out in a test of the experimental generator (top left) in a New York State valley. In similar tests the M-1 did the same job faster and more completely

generators was tried at an Atlantic port where important naval operations were under way.

On 10 out of 11 days, this haze not only hid all outlines of the earth beneath them from watching flyers, but persons on the ground in the area of operation found they could continue their work with little handicap. In November, 1942, when United States forces made their landings in North Africa, companies of smoke troops, armed with these generators which had not been in existence five months before, proved the worth of the new device on foreign soil. Later it was announced that a smoke screen had been thrown over the Panama Canal as a test, which effectively obscured that military target for many miles.

Today the tactics of large-area smoke screening are being developed rapidly. Each area to be obscured has to be treated according to local conditions of wind, weather,



Vehicles can protect themselves by emitting smoke. Small portable apparatus attached to cars, trucks, and mechanized equipment will cut down the chances of dive or contour attacks by enemy planes. At sea, too, the new fog armor is expected to prove valuable, as it is more effective than the usual smoke screen

and terrain, which vary from day to day, but which have certain averages. Generators ordinarily are stationed at selected points to windward of the places to be screened, and are moved as the wind shifts.

In case of air-raid alarms, smoke blankets are started from the generators closest to the most vital points for protection, the distance depending on how hard the wind is blowing. A second line of generators then starts to work some 400 or 500 yards to windward. As their smoke reaches the vital point and covers it, the generators originally closest in will be moved back to positions still farther to windward.

As soon as an unbroken smoke blanket extends from the outermost generators to the vital point, such as a factory, power house, or dock line, the area of the blanket will be gradually enlarged by moving generators constantly backward until finally the beginning of the screen may be several miles from the point which enemy aviators presumably are seeking.

The generators farthest back from most vital targets will be located on broken lines, so that the smoke or haze does not necessarily appear as artificial to an enemy bombing pilot, but may produce the illusion of a natural phenomenon.

Around a harbor, on lakes or rivers, the generators may be placed on barges when necessary to get them upwind, and special barges have been designed for the purpose. This obscures shore lines.

It is easy to imagine the difficulty with which a bombardier is faced when he finds himself over a target covered with smoke for many square miles. He must either drop his bombs indiscriminately in the smoke with a faint hope that they will damage some important installation in the area, or he must find a target that is uncovered in some other area. That choice is not an easy one.

If a pilot has come several hundred miles with a mission of bombing a power station or an oil refinery and knows that his target is somewhere within the smoke, he may be inclined to take a chance and hope that his bombs will reach their objective. An alternative target which may have been assigned may also be screened or it may be protected by powerful antiaircraft artillery defenses.

The American theory of bombing lays great stress on accuracy. Our Air Force believes our bombardiers can hit a reasonable percentage of their targets. We believe that point bombing is more profitable than area bombing. Smoke properly placed makes point bombing impossible.

In the daytime the screen is wide enough and high enough to cover not only the vital target, but also most aiming points or landmarks by which a bombing plane flies toward its goal. At night a dark-colored screen not only obscures a target but also camouflages all its surrounding region. Gray smoke, even in the moonlight, has all the appearance of a body of water when seen from high altitudes. A pilot or navigator, seeing what looks like a large lake where he expected to see land, may become confused as to his position.

The development of this new machine for large-area smoke screening, capable of producing 50 to 100 times as much smoke with less cost and less human effort than any previous smoke apparatus, is one of the major triumphs of American science in helping to fight the nation's war.

By the aid of industry, the size of present smoke generators should soon be cut down, so they will be easier to handle and consume less cargo space when shipped overseas. The M-1, now the Army's standard, is far heavier than future machines will be. A model which is only a small fraction of its size has been developed, and should soon be in production.

Used today exclusively by soldiers, these generators are so simple to operate and maintain and require so little heavy labor that there is no reason why they should not be operated within the zone of the interior by limited-service troops or by women. Their operation by WAACS has been considered, to release fighting men in some areas for other duties.

WHAT *Curiosity* CAN DO FOR YOU

★ ★ ★

A Story of Willis R. Whitney

WHY DO TURTLES go downhill in the fall and uphill in the spring? How can you tell the age of an Indian arrowhead? Do ants have nervous breakdowns? Do *you* know? Have *you* ever wondered? These are some of the many things Dr. Willis R. Whitney is interested in finding out.

● Now Dr. Whitney isn't, professionally, an expert on turtles or ants or arrowheads. He's a chemist. But he's found answers to all these questions because he's just naturally curious about everything.

Which is one reason why he's done so much for all of us, and also why he is one of the most respected scientists in America—besides being the founder of the General Electric Research Laboratory.

● It was back in 1900 that Dr. Whitney came from M.I.T., where he was teaching chemistry, to start a new kind of laboratory for G.E. At first he spent only half his time on the new job, and had only one assistant. Today the Research Lab has several hundred trained scientists working on problems of electricity, chemistry, metallurgy, and other sciences. And the scientific adventures of these men have helped produce better lamps, radio tubes, X-ray tubes, and many other products we use every day.

● Dr. Whitney believes in what he likes to call "fool experiments." But they generally turn out not to be foolish at all. From one of them came a lamp filament twice as efficient as Edison's early ones. Another showed that radio waves can produce artificial fevers for treating disease. And he's suggested thousands of important experiments for others to perform.

● Perhaps the most valuable of Dr. Whitney's experiments was the laboratory itself. His ideas have guided its growth; over the years hundreds of young scientists have been inspired by him to be curious about things, to ask questions, and then to try experiments to get the answers.

● Dr. Whitney once said, "Somebody is always reflectively monkeying with some of the parts of an infinite universe." He's done a fair amount of such monkeying himself; he's still having a lot of fun doing it. And he believes that anybody endowed with a normal amount of curiosity who does the same will have fun, too, and will perhaps make valuable contributions to our knowledge and to the world's progress. *General Electric Co., Schenectady, N. Y.*

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Guarantee

YOU ARE THE JUDGE—

Add Casite to crankcase and run through carburetor according to instructions, then drive your car 100 miles or for 60 days, whichever is first. If not convinced that Casite gives you **better and smoother performance,** you get double your money back by filling out guarantee certificate and mailing it to The Casite Corporation, Hastings, Michigan. Maximum refund is $1.30 per pint, which is twice the nationally advertised price of Casite.

CASITE

CLEANS OUT MOTORS · KEEPS MOTORS CLEAN

How Detroit Builds Guns

(Continued from page 108)

sent them from plant to plant to teach simplified methods for intricate jobs.

"Subcontracting is the auto industry's middle name," said S. E. Skinner, general manager. "We at Olds have made it our first name as well. Our results have been excellent and our problems have been no greater than those we normally encounter in making automobiles."

There were problems, of course, some of them with their humorous aspects. One of the most difficult subcontracts, involving a tolerance of only one half of one thousandth of an inch, was given to a thoroughly competent tool-making shop in Detroit. When the parts were delivered, the inspectors found them more than a thousandth off gauge. Olds protested. The toolmakers insisted they were right. But the next delivery again was off. Belligerently Olds engineers put the offending parts in a car, took along their inspection gauges, and drove to Detroit. Arriving at noon, they went to lunch with the subcontractor, then returned to the shop to demonstrate that the parts were entirely off specifications. Much to their amazement, when they applied the gauges, the parts were practically perfect. During the lunch hour they had lost the chill acquired in transportation from plant to plant. It was a part that will vary by three thousandths merely from body heat.

Hardly had Olds got under way with 20-mm. production before Pearl Harbor changed everything. At Olds, as elsewhere, automobile production lines were scrapped. Olds took contracts for 37-mm. and 75-mm. guns, converted some machinery, brought in hundreds of new lathes, broaches, and other precision machines. All its acres are given over to the turning and assembly of war's barking tubes of death. But still the subcontracting technique holds true. On each of its three major jobs, Olds itself manufactures only three parts.

Take the 37, for instance. Olds makes the barrel, the tube extension, and the lock frame. The other parts are made by 68 subcontractors in shops scattered over 35 cities and towns in 10 states of the East and Middle West. And only 18 of those 68 subcontractors were doing business with Olds in the days of automobile manufacture.

Multiply that by a few thousand times, remembering that one type of gun is only one small item among all the infinite variety of jobs that go to make a plane, a tank, or any of the other engines of war. The trun-

(Continued on page 200)

AUTOMOTIVE SPARK PLUGS—built by AC since 1908.

Awarded to the men and women of AC on September 2, 1942, for outstanding achievement in producing for Victory.

YOU REMEMBER "Suzy-Q"—famous Flying Fortress that destroyed every Zero attacking from the rear. She was one of the first with .50 caliber tail "stingers"—like those AC has been building *since nine months before Pearl Harbor.*

Aerial gunners know that the shattering blast of those machine guns must be "on tap" all the time. So, those guns are cleaned, oiled, and adjusted after every trip aloft. Marvels of precision workmanship, the guns nevertheless need service to keep them in fighting trim.

Expert Care for Your Spark Plugs

The same thing is true of the AC Spark Plugs which fire the engine of your car, truck, or tractor. Symbols of quality and performance to millions of motorists; these plugs need cleaning and adjusting every few months. This service is easy to get. Every mechanic—everywhere—renders valuable conservation service. This is being augmented, now, by trained AC service men who are carrying to all service organizations the latest methods of diagnosis and repair of AC products. (The panel below indicates what this service is, and why you need it.) We urge you to follow the simple suggestions—to save gasoline, oil, and tires.

When replacement is needed, select AC—and be sure of complete satisfaction.

AC SPARK PLUG DIVISION
GENERAL MOTORS CORPORATION

OIL FILTERS—Slow driving accelerates the formation of soot and carbon in engine oil. If not constantly filtered from the oil, this dirt will clog piston rings, which causes increased consumption of oil and gas. So, replace your oil filter element whenever your dealer's AC Oil Test Pad shows that your oil is dirty.

SPARK PLUGS—Dirty or worn plugs waste as much gas as one coupon in ten. They also cause hard starting which weakens your battery. Under present slow driving conditions, have your plugs cleaned and adjusted every few months.

AIR CLEANERS—A dirty air cleaner increases gasoline consumption because it chokes down the flow of air into the carburetor. Your air cleaner should be rinsed whenever your car is lubricated.

FUEL PUMPS—Practically trouble free. But, if yours has been in use thirty or forty thousand miles, it may be worn to the point where a check-up is due.

DRIVING INSTRUMENTS—Speedometer, gasoline gauge, oil pressure gauge, ammeter, and temperature gauge seldom need service. But, if they give trouble, have them cared for *at once.*

BRING VICTORY QUICKER—BUY U. S. WAR SAVINGS STAMPS AND BONDS

THE "Pals" THEY LEFT BEHIND

are Harley-Davidsons

Letters continue to pour in from men in the armed services telling how they miss the Harley-Davidson Motorcycles they left behind. One outstanding feature of ALL these letters is the way every man speaks of the stamina, power, and rugged dependability of his Harley-Davidson "sweetheart." And they look forward to the day when they can again thrill to the ownership of new Harley-Davidsons — motorcycles with greater performance than ever, made possible by the severe tests of wartime action.

HARLEY-DAVIDSON MOTOR COMPANY
Department PS.
Milwaukee, Wis.

Write today for your FREE copy of "Enthusiast" magazine, filled with motorcycle action pictures and stories.

HARLEY-DAVIDSON MOTORCYCLES

How Detroit Builds Guns

(Continued from page 198)

nion block of the 37-mm. gun, which must be held within .0005 inch, is being made by a company that used to make package machinery for the canning industry.

The acres of floor space at Olds devoted to making 75-mm. guns had been, in 1941, a vast assembly line, where men were putting on wheels, tightening nuts, fitting fenders—all the partly skilled jobs that automobile production involves. But today the assembly line for the 75 gun is only 75 feet long. Joe Smith, who in 1941 was tightening tire lugs, today is running a broaching machine that cuts out the insides of a breech ring in one tenth of the time it used to take. Joe Doakes, who used to do rough sheet metal work, today is doing the delicate machining of a powder chamber.

There always was precision work in making the engines and running gear of automobiles, but today that precision work and the number of precision workers have been multiplied—not only in the main war plants, but also in thousands of small-town parts factories. And in the same way, techniques of management, tricks of production, and hidden secrets of metallurgy have been spread through America at a rate we could not have imagined five years ago.

And while production skills thus multiply in the gun factory, at a building near by hundreds of soldiers and sailors every three weeks are learning the intricate skills of maintaining the guns, taking them apart and putting them together blindfolded—just as thousands of other military men in other schools are learning the intimacies of airplane and tank engines and all the other complex instruments of war. Before the war America led the world in number of skilled mechanics. We will have millions more of better ones after the war.

Bill White, screwing on nuts, never knew he could run a lathe. Farmer Jones's son never knew he could doctor an airplane engine. The small town manufacturer never knew he could make as good a gun part as the next fellow. The symbolic Detroit suspected, but it did not really know, that it could convert itself overnight into an invincible armament industry—that it was a method of organization, planning, and teaching, able to lick any production job.

Subscribers in the armed services who notify us of change of address are requested to give us the key symbols appearing on the wrapper in which the magazine is received.

THREADS THAT LIVES MAY HANG ON

The lives of flying crews may hang on the threads of nuts which stay put – hold fast against the chatter of gunfire, the throb of pulsing engines.

We make such a nut. We have made more than three billion of them. And as far as is known, not a single one of these nuts has ever failed in service.

It is the special virtue of Elastic Stop Nuts that they never loosen, slip, shake off or break.

Small wonder they are used on every airplane made in America – as many as 50,000 in a single ship.

Some day these nuts will be available for purposes other than the grim jobs of war.

When they are, automobiles will be tighter and safer and quieter – everything from garden tools or farm tractors to radios and vacuum cleaners will give longer and less troublesome service.

But that's for the future. Today, all these tenacious nuts we can make go for an even more important purpose – which is the simple task of holding tight till the war is won.

LOCKED on bolt by the action of the hardened celluloss collar
SEALED at top to protect working threads from corrosion
HOLDS nut thread against bolt thread — prevents axial play
FITS any standard bolt. Made in all sizes and types

Radio sets will last longer, keep a truer tone, with Elastic Stop Nuts holding important fastenings firm and tight.

Washing machines call for nut and bolt connections that stay tight under heavy use. Elastic Stop Nuts keep such appliances running right.

When regular nuts loosen, cars squeak. So look ahead to quieter automobiles after victory is won.

On a lawn mower, ordinary nuts may loosen, fall off, get lost in deep grass. Elastic Stop Nuts stay put.

ELASTIC STOP NUTS

Lock fast to make things last

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA
UNION, NEW JERSEY

Photo by U. S. Army Signal Corps

WE MUST NOT "let him down" with poor equipment! See those snap buckles? They help to harness him securely to his parachute. They've got to be strong—light—smooth—and without defects!

They're forged from tough alloy-steel. Then files of high quality, and proper cut and shape, are used to remove all fabric-wearing burrs and roughness—to prepare the buckles for plating or polishing.

As in the case of hundreds of other important industrial filing operations, Nicholson makes and has helped to select *The right file for the job.*

Seventy-nine years of experience reflect Nicholson's ability to make the best possible files for every kind of work, material and desired result. Nicholson and Black Diamond are the top-honor brands in this world-famous line of quality files.

FREE **— NEW BOOK, "*FILE FILOSOPHY*,"** for production and purchasing heads, foremen, key mechanics. Tells about the more frequently used of 3000 kinds, cuts and sizes of files Nicholson makes; about files for special purposes; how to use, care for and select the right file—48 interesting pages.

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NICHOLSON FILES *FOR EVERY PURPOSE* NICHOLSON U.S.A. MADE IN U.S.A.

Precision Bombing

(Continued from page 44)

unhealthy if one decides to slow down for a look around at that height. One has to duck into nests of hostile defenses, dropping delayed-action bombs which, if they exploded on contact, would destroy the airplane as well as the target.

This light bombing is used against enemy airfields, small installations, radio-location stations, minor rail junctions, etc. Its main value is that the light bomber can blunder out into weather that would ground the heavy bombers and thus keep the Continent's defenses on alert watch at all times. Cut-down visibility means little to these ships which, equipped with awninglike flaps and tricycle landing gear, can slip in and out of the dawn Channel fog, making life unpleasant for the coastal defenses in France, the Low Countries, and even West Germany.

Other equipment takes part in this low-level attack. The newest entry is the stinging De Havilland Mosquito, a twin-engined terror built entirely of resin-bonded plywood, which can divide one ton of payload between guns and bombs and move in at pursuit speed. There are only two German fighter planes in existence capable of matching the Mosquito's level speed. Low-level bombing is just one of the ship's many talents. Its general operation procedure in this class is to come in on target at tree-top level with its low-speed superchargers in operation, lay its eggs on target, cut into high blower, climb like a rocket, and get out before the startled defenses have a chance to gather their wits. Specially rigged Hurricanes, Spitfires, Mustangs, and Warhawks, carrying light bomb loads, sometimes drop in for surprise visits.

There is comparatively little day mid-altitude bombing over the Continent. This has proved the most dangerous type because the equipment is within the best operational range of the antiaircraft and fighter defenses. For a reasonable amount of crew safety, almost as much weight must be invested in defensive armament as would be installed in a heavy bomber. These ships have been found most effective in areas where the opposition is from fighter craft rather than from ground installations.

There is, however, a fairly safe operational altitude for these craft. This is the zone where the accuracy of the light antiaircraft weapons has seriously fallen away, yet the altitude is not high enough for correct fusing of the heavier explosive shells. From this altitude the medium bombers have been

(Continued on page 204)

Pegging Shoes Didn't Leave Much Time for School

Little William Douglas had to get his first schooling piece-meal. Pegging shoes long hours in an attic workroom at the age of seven, he still found time to attend the rural school, two miles away. Later, working hours improved and he could go to school regularly.

THE FLEETWOOD—Comfortable Brogandi oxford in rich tan leather—rugged sole—rubber heel. No. 4627

THERE'S A LIFE TIME OF "KNOWING HOW" IN W. L. DOUGLAS SHOES

Maybe you've wondered what makes W. L. Douglas Shoes so uniformly good—so *satisfying*—wondered what the *difference* is.

It's simply that W. L. Douglas Shoes are made today as only young Douglas knew how to make them.

Because he had to learn his trade the hard way, William Douglas learned it the *right* way. He learned to make fine shoes—*great* shoes. And we at Douglas have never unlearned his lessons.

That's the reason you like our shoes so much today.

There's the master touch of young Douglas in them—a lifetime of "knowing how."

THE COMMANDER—Service men and civilians choose this tan military type oxford, for all-day walking comfort. No. 4563; in black, No. 4035

Douglas "Down-to-the-Wood" construction assures better fit.

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Stores in Principal Cities—Good Dealers Everywhere

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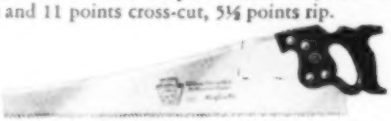
SAWS FOR THE WAR EFFORT

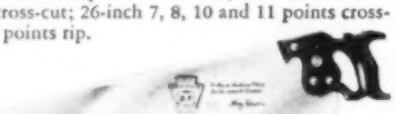
In accordance with WPB limitation order, Disston is manufacturing four Disston Hand Saws and two Keystone made-by-Disston Hand Saws as shown below . . . If you are doing essential work, see your Hardware Dealer about one of these fine saws:

D-43 Victory—Lightweight Straight-back pattern, the finest saw in the Disston Line. Made in 26-inch 7, 8, 10 and 11 points cross-cut, 5½ points rip.

D-23 Lightweight Straight-back pattern. Always popular with saw users demanding quality and workmanship. Made in 24-inch 8 and 10 points cross-cut; 26-inch 7, 8, 10 and 11 points cross-cut, 5½ points rip.



D-8 Medium weight, Skew-back pattern, "The Saw Most Carpenters Use." Made in 20-inch 10 points cross-cut; 22-inch 8 and 10 points cross-cut; 24-inch 8 and 10 points cross-cut; 26-inch 7, 8, 10 and 11 points cross-cut, 5½ points rip.



D-7 Lightweight Straight-back pattern. Universally popular moderately priced Disston quality. Made in 26-inch 7, 8, 10 and 11 points cross-cut, 5½ points rip.

K-6 Challenger, a popular priced Keystone made-by-Disston Skew-back saw. Made in 26-inch 8 and 10 points cross-cut, 5½ points rip.

K-4 Airmaster, a popular priced Keystone made-by-Disston Straight-back saw. Made in 26-inch 8 and 10 points cross-cut; 5½ points rip.

MAKE TOOLS LAST with the help of the instructive Disston Saw, Tool and File Manual—FREE from your hardware dealer, or write to us for your copy.

HENRY DISSTON & SONS, INC.
710 Tacony, Philadelphia, Pa., U. S. A.

Precision Bombing

(Continued from page 202)

used with good effect against secondary targets and for diversionary action in support of the heavy ships by day or by night.

These ships have an operational method similar to that of the heavy ships. Their bombing method is a precision run up to the target under the control of the bombardier, who uses our regular automatic bombsight. There are two basic uses in Europe for ships of this class. The first, as previously stated, is for direct action against secondary objectives which do not warrant the attention of heavy bombardment. The second—and, in the European theater, the more important—is the diversionary function—pulling fighter power away from important target areas, thus leaving them open for direct punishment by the heavy bombers.

Our equipment in the medium-bomber class consists of the Martin B-26 (Marauder) and the North American B-25 (Mitchell). In the medium class the British still use the Wellington and the Maryland, although in some circles the Bristol Beaufort is put in the same category.

The brunt of the attack, the final blows that will paralyze the Reich and leave it stunned and inert, ready for invasion, will come from the heavies—the four-engined class which night and day will haul weight over the Continent to flatten the 150 vital areas. The division of the job into day and night bombing was dictated by a practical application of the men and ships available.

The general air strategy was to allow the American equipment and crews to operate by day in their high-precision raids while the R.A.F. performed their pattern or area bombing at night. One has only to study the history and background of both bombardment organizations to mark the wisdom of that decision. The B-17 design was developed in the old days when an isolationist-minded nation saw the air problem in terms of defending the United States from our own shores. The military objective of the Flying Fortress class was to create a ship that was capable of sinking the individual units of a potential invasion fleet, ship by ship, in midocean. The basic assumption was taken from the automatic bombsight and the amount of explosive projectiles it would take to sink a capital ship at 70 percent efficiency. The closely integrated crews and their training setup was based on this kind of operation—hitting an exact target with a four to five-ton explosive load from levels above the optimum range of antiair-

(Continued on page 206)

You may worry about missing the boat

but here is one worry you can avoid

YOU can "miss the boat" these days, if you lose the use of your car. And lose it you may, if irreplaceable engine or chassis parts break down.

Even though you drive your car much less, it needs regular care. Batteries go dead for lack of use, tires need constant checking. Water and sludge in crankcase may rust idle bearings and pistons. Scale and rust can ruin your radiator.

Avoid such worries with Marfak 40-Point Chassis Lubrication Service. Your dealer checks your car, point by point, from fan to differential *against his Marfak chart*. No guesswork here. Marfak means *accurate* protection for every vital part.

That's why your car is *right*, when it's had Marfak Lubrication—*right* for keeping it on the job for you and Uncle Sam. Insist on genuine Marfak Lubrication. At Texaco and other good dealers everywhere.

TUNE IN: FRED ALLEN every Sunday night. See your local newspaper for time and station.

You're Welcome at **TEXACO DEALERS**

Raiding with the Rangers, 'cross country scouting, front line dispatch riding . . . those are some of the motorcycle jobs that call for red-blooded riders with daring and courage, cool heads and resourcefulness.

In flashy, flexible performance on a dozen battle fronts, Indian Motorcycles are backing up these riders with all of Indian's famous power and speed and sturdy dependability. The soldier who rides an Indian knows there's no safer motorcycle built.

And you'll know it, too, when you ride the great new Indians that will be yours for good times and economical transportation after this war. In the meantime, let your Indian dealer help keep your present motorcycle in fighting trim . . . and ask him about his reconditioned "buys".

INDIAN MOTOCYCLE COMPANY, SPRINGFIELD, MASS.

Indian

BUY WAR BONDS NOW

★ ★ TO BUY AN INDIAN LATER ★ ★

Precision Bombing

(Continued from page 204)

craft, or at altitudes of 28,000 feet and up.

Britain lived closer to the problem. In the days before the American equipment was available, the spot precision bombing was done by medium bombers, but the loss rate was quite high. Therefore the heaviest bombing was done at night. The British theory of night bombing was that if enough explosive was dropped into a particular area, by the law of averages part or the whole of any objective inside it would be demolished. The problem resolved itself to a simple job of getting the greatest possible amount of weight over a predetermined area under the cover of darkness, dumping it, and high-tailing for home.

Up to this point the joint effort has worked out quite satisfactorily, for the equipment has been used for the jobs for which it was built. Any other application would be a waste of equipment and effort. One of the greatest shortcomings of our Fortresses and Liberators is being remedied by equipping them for flying and fighting at night. This will enable them to take advantage of the cover of darkness for one leg of a long round-trip bombing flight. They will time their raids to put them over the targets at dawn or dusk, when the bombsight can be used, with only half of the trip exposed to daylight dangers.

What kind of bomber will the near future bring forth? It is conceded that neither the American nor the British bomber is ideal for all-purpose, 'round-the-clock operation. It would, in operational theory, be desirable for one design of ship to be able to operate around the clock and, by adjustment within the structure, answer all purposes. Several experts have offered opinions as to what this design might look like, and the consensus is represented by the drawing on page 45.

This may be the ship of the future. However, the current battle must be fought with the designs on hand. Fate played Hitler a nasty trick when the United Nations, watching for him on a variety of fronts, developed an equal variety of aircraft types. If we can, from this day forward, provide sufficient numbers of aircraft and crews by accelerating production and training, the Axis' days are truly few in number. For the hour the United Nations airmen can put the major enemy nerve and production centers out of action simultaneously, invasion is just a step across water. This, however, takes bombing—heavy and unceasing, by day as well as by night!

Guns That Stalk Their Targets

(Continued from page 122)

connected with the Ordnance Department. The late Plinty Holt, inventor of the caterpillar tractor, and Christie were active both in designing and manufacturing mounts.

In 1920 two Ordnance-designed Mark VII motor carriages were built by the Holt Tractor Company, one for the 75-mm. gun and the other for the three-inch gun and the 105-mm. howitzer. These carriages were the first to carry the gun with its muzzle pointing forward—one of the big advantages of modern self-propelled mounts. Their weight was under six tons and their V-8 72-horsepower engines gave them a speed of 30 miles per hour, which was considered so much too fast that it was reduced by two thirds. They could climb a 35-degree slope and cross a 34-inch-deep stream, and they burned only half a gallon of gasoline per mile. Rubber blocks were used to absorb shocks. The gun crews were protected by removable front and side shields. Men who worked on the Mark VII's say that they would be rated good self-propelled guns even by present-day standards and that the Germans made no mistake when they modeled their 105-mm. self-propelled howitzer after them.

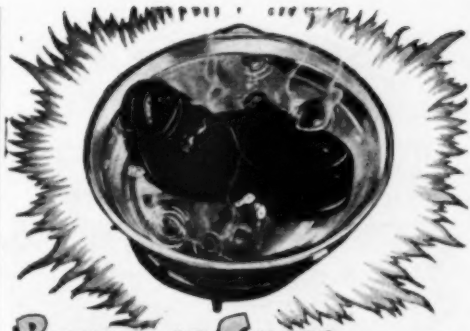
The Christie motor carriage for the 155-mm. G. P. F. gun also was produced in 1920. It weighed 20 tons, and its speed was 15 miles per hour. Like most Christie combat vehicles, it used both wheels and tracks. Adjusting the removable tracks over the wheels was a half-hour job. Six 33-ton track-laying mounts for the 155-mm. gun or eight-inch howitzer were built and service-tested shortly afterward. The following year two Christie carriages for the 75-mm. gun or 105-mm. howitzer were built. They weighed about eight tons and had a top speed of 20 miles per hour.

Then for several years meager appropriations restricted development to the rebuilding and improving of existing models. In 1928 a mortar mount was built on the chassis of a T-1E1 tank. Two years later the T-1 motor carriage for the 75-mm. pack howitzer was produced. It weighed six tons and could do 21 miles per hour.

The T-1 was the last self-propelled gun built in America until the Nazi blitzkriegs in Europe showed how essential these weapons were in mechanized warfare. Until they were broken up for scrap metal, the old mounts were preserved as curiosities or allowed to rust on scrap heaps at the arsenals.

But that effort and money wasn't wasted. Since the M-7 made its sensational initial

(Continued on page 208)



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REMARKABLE RESULTS WITH QUINSANA

74% infected before Quinsana treatment

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CLEARED UP PRACTICALLY ALL OF THOUSANDS OF TEST CASES OF ATHLETE'S FOOT. USE **QUINSANA** DAILY FOR PREVENTION AND RELIEF. ALSO EXCELLENT FOR EXCESSIVE PERSPIRATION, FOOT ODOR.

Use Quinsana on feet daily to help prevent and relieve infection

Shake Quinsana into shoes to absorb moisture, reducing chances of re-infection

50¢ FOR ATHLETE'S FOOT

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... Says PAN AMERICAN WORLD AIRWAYS SYSTEM

Boldly blazing new sky trails ... steadily thrusting our air frontiers across farthest oceans and continents ... the far visioned pioneering of Pan-American World Airways forms one of the most brilliant chapters in aviation history. And wherever Flying Clipper wings have soared over world-wide routes, Snap-on tools have played their part.

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Snap-on tools are endorsed by every leading air line ... widely used in the greatest aviation plants ... and by the skilled maintenance crews of our Flying Forces. In thousands of busy war plants, where tool speed and accuracy count heavily, Snap-on tools are *the choice of better mechanics.*

SNAP-ON TOOLS CORPORATION, Kenosha, Wis.

Guns That Stalk Their Targets

(Continued from page 207)

appearance at El Alamein, much has been written about the fact that its production layouts were drafted in 16 days and that three weeks after the blueprints were completed the first models were being tested. That would not have been possible without the know-how acquired by our Ordnance Department during its decade of pioneering.

Meanwhile, the Germans were emphasizing the importance of self-propelled guns pointing in the direction of the march, but in spite of these views published widely in Germany as early as 1936, actual use of this type of weapon came as a surprise. Most important of the Nazi self-propelled guns are the 75-mm. assault gun, 105-mm. howitzer, 105-mm. gun, and 150-mm. gun. One captured by the British is a 150-mm. howitzer on the chassis of a French Renault light tank.

Our real start came two years ago with the realization by Brig. Gen. Andrew D. Bruce, then a lieutenant colonel on the General Staff, that the best way to beat tanks is with quick-acting, high-velocity guns. It would take even the smartest crew, he reasoned, about 40 seconds to unlimber its gun from a truck, swing it around, and fire. In that time a tank could approach within range, stop, and still have 10 seconds to fire several carefully aimed shots. What we needed were guns that would always be pointing the right way and could be fired the moment an enemy tank was sighted.

Bruce was put in command of an experimental tank-destroyer battalion, and the Ordnance Department made up for lack of self-propelled guns by combining standard guns with standard vehicles. It delivered over 50 in two months. Our 75-mm. high-velocity tank gun mounted on a T-14 armored half-track scout car produced the M-3 motor carriage with a road speed of 50 miles per hour. It points forward, is mounted so the driver can remain in his seat when it is fired, and throws a projectile that will penetrate most tanks at 1,000 yards. Its three-man gun crew is protected by armor and a .50 caliber antiaircraft machine gun.

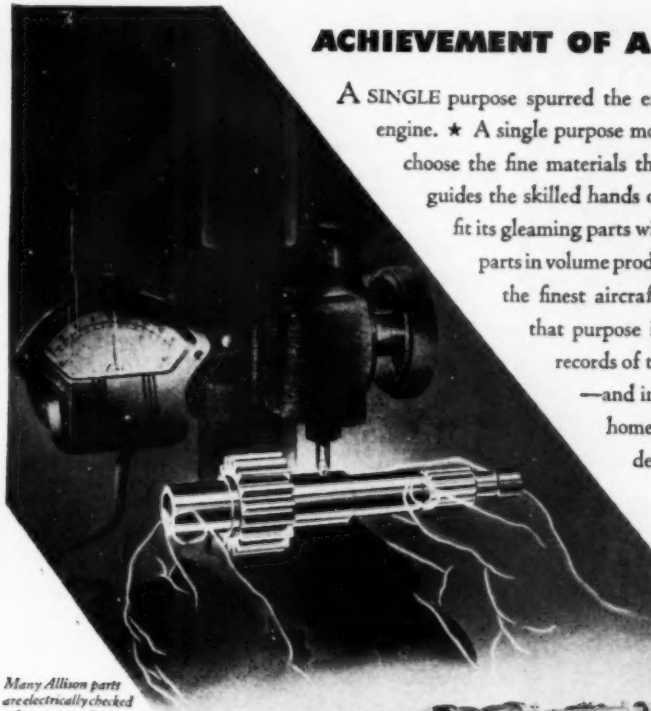
Lighter destroyers were made by mounting 37-mm. guns on jeeps and T-8 motor carriages (swamp buggies). Later the 37 was put on Fargo ¾-ton trucks.

Tested in maneuvers in the fall of 1941, the battalion was so successful that more were organized and a Tank Destroyer Command was formed with Bruce, promoted to

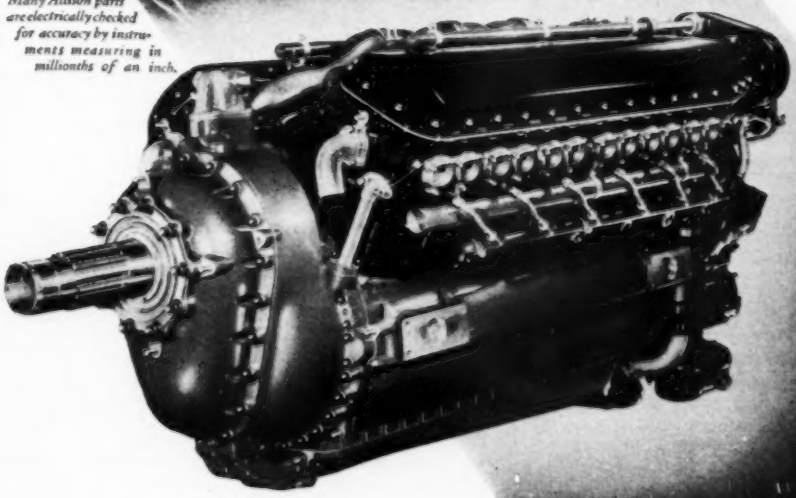
(Continued on page 210)

ACHIEVEMENT OF A SINGLE PURPOSE

A SINGLE purpose spurred the engineers who planned the Allison engine. ★ A single purpose moves the metallurgists who test and choose the fine materials that go into it. ★ A single purpose guides the skilled hands of the craftsmen who machine and fit its gleaming parts with precision that finds few counterparts in volume production. ★ That purpose is to create the finest aircraft engine ever built. ★ How well that purpose is attained is being written in the records of the planes which the Allison powers —and in the standards it is establishing, at home and abroad, for sturdiness and dependability. ★ Employed in several types of American fighting planes, the Allison is proving before the world the ability of America to work to levels of quality and exactness never before approached.



Many Allison parts are electrically checked for accuracy by instruments measuring in millionths of an inch.



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WILLIAMS
SUPERIOR DROP-FORGED TOOLS

Guns That Stalk Their Targets

(Continued from page 208)

brigadier general, at its head. Lieut. Gen. Lesley J. McNair, chief of the Army Ground Forces, gave Bruce full credit, remarking that seldom has one man both the vision to conceive such a project and the ability to carry it through to full bloom.

The motto of the tank-destroyer units is "Seek—Strike—Destroy." They have but one mission, destruction of enemy tanks. Superior speed enables them to beat the enemy to positions of ambush, and superior guns enable them to make the kill.

Our new three-inch antitank gun, only 1/20 inch larger in caliber than the 75, has a longer barrel and uses a much heavier charge. A single solid hit will disable any known enemy tank up to—and probably well over—2,500 yards. Still another anti-tank gun is smaller than the 75, but has greater armor-piercing power.

Nicknamed "The Priest" by the British because of the altar-like appearance of its machine-gun mount, the new 105-mm. self-propelled gun-howitzer is an eight-foot-long, 1,200-pound, mechanized support gun for armored divisions. It is an ideal all-purpose weapon. Used as a gun, it has a fairly high velocity and a fairly flat trajectory, and its 33-pound, 4.1-inch-diameter projectile will penetrate medium-tank armor at 2,000 yards. As a howitzer, it has an extreme range of over seven miles, throwing high-explosive shells at a high angle to destroy emplacements protected from direct fire. Its speed of over 35 miles an hour enables it to keep up with fast tanks on the march and to outmaneuver German medium tanks.

Even newer is the M-10 tank-destroyer mount (P.S.M., May '43, p. 72), already battle-tested in North Africa and now being produced in quantity. Although the M-10 is a full-tracked vehicle with heavy welded armor plate, it is faster than most tanks, and its high speed and low silhouette make it a difficult target. It carries a gun that is larger than the 75, packs a mighty wallop, and is more than a match for the German 88-mm. converted antiaircraft gun.

Newest and biggest of all is the M-12 motor gun carriage, which mounts our 155-mm. gun. Utilizing the chassis of an M-3 tank, this highly mobile weapon can throw a 95-pound projectile more than 10 miles and could knock out the biggest tank or even sink a heavy cruiser at that distance. This juggernaut on tracks is especially effective against enemy artillery and fortifications and can work in any terrain suitable for operations of medium tanks.

IN A TAPERED ROLLER BEARING

COUNT THE ROLLS...
...THE ROLLS COUNT!

☆ The number of rolls in a bearing is of utmost importance—for **rolls carry the load.**

Obviously, **more** rolls carry **more** load. And, with the load distributed over more rolls, each roll has a smaller part of that load to carry. Result: longer bearing life.

Thanks to improved design, Tyson is able to add more rolls around the raceway—about 30% more, on the average. Size for size, the Tyson "All-Rolls" Bearing has more load capacity . . . has longer life . . . has greatest rigidity.

Tyson

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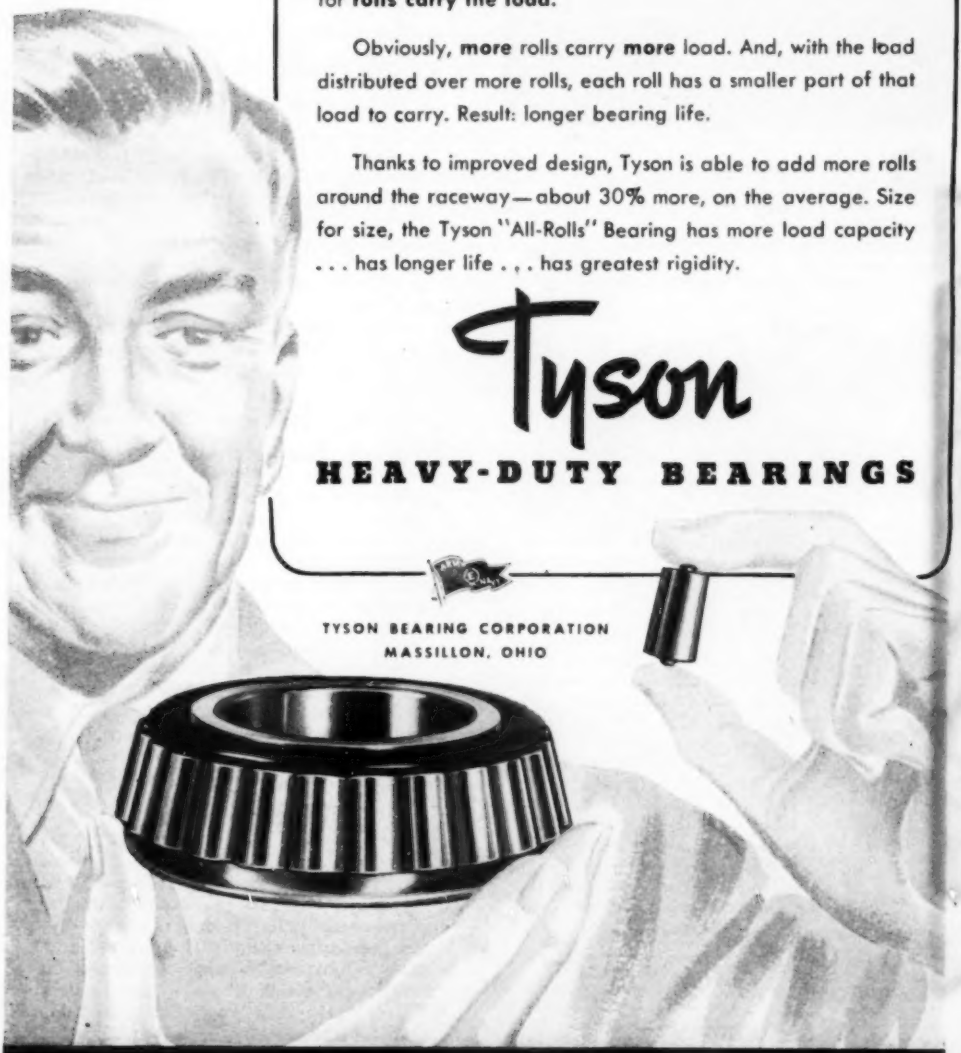

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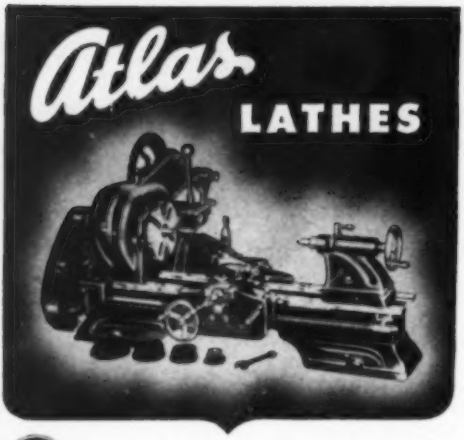
Tyson Products also include precision parts for America's airplane engines



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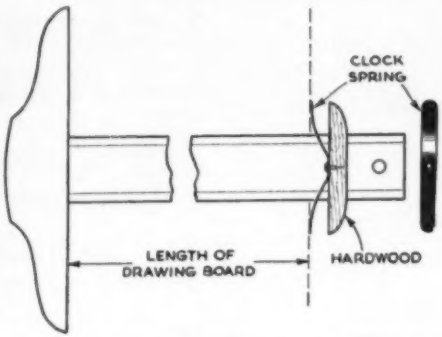
Spring Mounted on T-Square Holds It in Position



TO PREVENT a T-square from falling off the drawing board and to keep it aligned, the method shown above may be used. Cut a portion of clock spring to size, punch a hole in the center, and grind off rough edges. After shaping it as shown above, screw it to a piece of hardwood, which in turn is screwed to the blade of the T-square at such a distance that sufficient tension is obtained in the spring when the square is fitted to the board.—EUGENE MERKIN.

Rubber Suction Cup Keeps Ash Tray from Sliding

A METAL ash tray can be prevented from sliding around on a polished surface or a glass-topped desk by drilling a small hole in the center of the tray and attaching an ordinary rubber suction cup. If the tray is glass lined or cannot be drilled for any reason, use a double suction cup instead of a single one. Picturesque ash trays for a seaside cottage or summer cabin can be made from large clam shells by drilling them and adding suction cups so that they will rest firmly on the table.—J. R. DICK.

Push Button Prevents Shorts as Child Plays with Train

TO LET a young child play with an electric train in safety, connect a door-bell button in series with the track and transformer. The train will run only while he holds down the button. Should it jump the track, a short circuit won't cause trouble because he will release the button to put the train back. If he tires of playing, the current is shut off automatically. However, be sure to disconnect the transformer from the house line at night.—HAROLD GRIMM.

Your Camera of Tomorrow

Although right now we are building for the Future, all our energies at the moment are concentrated on the protection of that Future by the manufacture of Precision Optical Instruments and Communication Radio Systems for our Armed Forces. . . . Out of the Crucible of War will come new ideas, new materials and new methods. Thus we are also building for you. . . . The apprenticeship we are serving under the taskmaster of war needs, is streamlining our designs, stimulating our ideas and strengthening the skills of our hands—These Jewels of Today will make finer Instruments and better Cameras for you Tomorrow.

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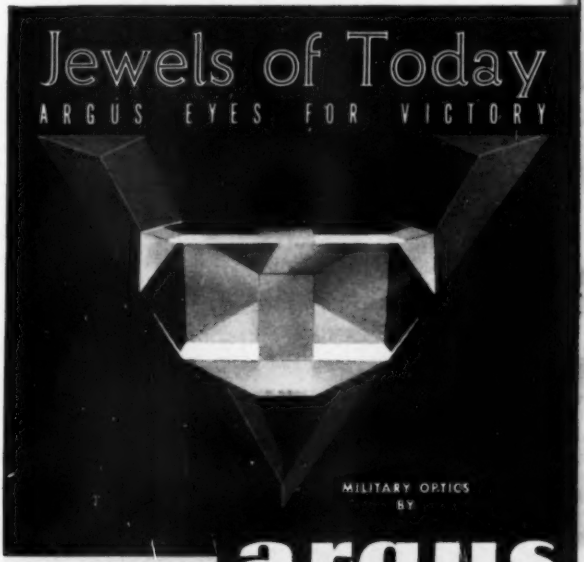

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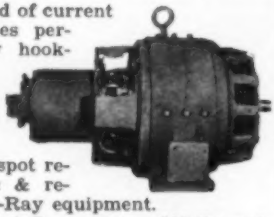
Katolight Generators and Power Plants



Furnish same kind of current as City power lines permitting emergency hook-ups right out in the field for operating repair equipment such as drills, grinders, saws, etc. for making on the spot repairs; transmitters & receivers; portable X-Ray equipment.

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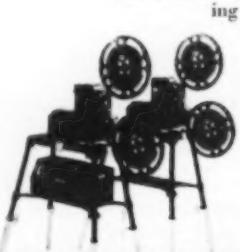

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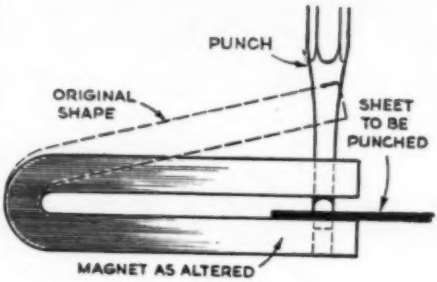
Chilled Lard Aids Craftsman in Cutting Glass Bottles

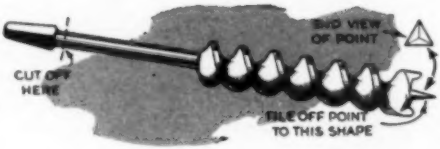
ONE way to cut off the top of a bottle or jar is to pour in melted lard up to the level at which the break is desired and chill the bottle in the refrigerator overnight. Then place it in a sink and pour in sufficient hot lard to cover the cold lard completely. In a few seconds the upper portion will snap off evenly and without chipping. The sharp edges of the glass may be rounded with a file and a coarse oilstone until smooth enough to handle.—STEPHEN CAVELL.

Handy Punch Is Easily Made from an Old Car Magnet



A MAGNET from a Model-T Ford can be made into a handy punch for sheet metal, clock springs, and the like. Heat and bend the legs of the magnet parallel as shown. Drill a hole through both for the size of punch desired. If you intend to punch holes in clock springs, the legs should be retempered.—C. G. GUTTINGER.

Auger Bit Used in Drill Press



TO MAKE an ordinary auger bit suitable for use in the drill press, cut off the square shank, then file off the thread of the spur. File the point to have three or four flat sides, similar to a pyramid. These flat sides form cutting edges that remove stock as they pierce the wood, whereas a cone-shaped point is likely to cause the stock to split because it forces the fibers apart instead of cutting them.—E. C. HANLEY.

A Tribute... and A Responsibility

When the men and women of Stanley Tools, Division of The Stanley Works, received the Army-Navy "E" award on February 13, it was a much prized tribute to a great production team. Of particular interest is the fact that it came during the one hundredth anniversary year of the Company.

Upon their shoulders has rested a triple burden. They have been called upon to supply (1) tools for the armed forces . . . to construct and maintain camps, bases, and barracks; (2) tools for war industry . . . to build plants, ships, planes, and other implements of war; (3) tools for the home front . . . to maintain farms, schools, institutions, and essential civilian industries.

Hand in hand with this honor for past performance goes a great responsibility for future performance. These men and women fully realize this responsibility. Far from being contented with the "contribution to Victory" already made, they are striving to make a greater contribution in the future. Stanley Tools, Div. of The Stanley Works, New Britain, Conn.

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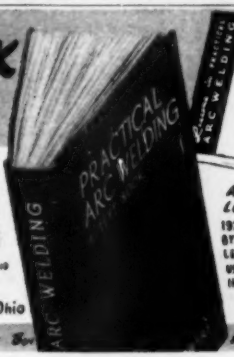

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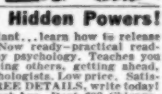

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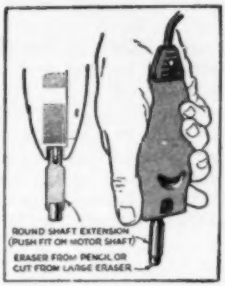


AN ELECTRIC razor can be easily adapted for use as an automatic eraser. Remove the razor head; then turn out an extension piece that will be a push fit on the drive shaft of the razor. A hole large enough to accommodate an ordinary pencil eraser is drilled in the end of this extension. The extra parts can be removed whenever the razor is to be used for shaving. It is best to use a hard eraser in the shaver, as the soft types tend to wear down too soon.—R. W. ZIEGE.

Boiling Hard Water Softens It for Photographic Use

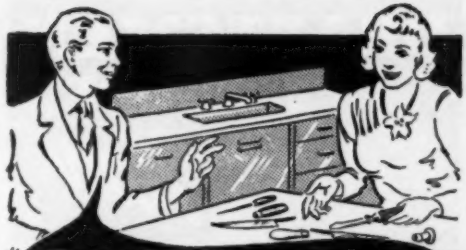
CALCIUM in the form of either calcium sulphate or calcium bicarbonate in tap water can cause considerable annoyance if the water is used for mixing developers. You can tell that calcium is present in some form if your tap water produces a milky precipitate the moment sulphite is added.

If calcium sulphate is present, a chemical treatment is necessary to precipitate it. Your water company can probably tell you how to use oxalic acid for this purpose.

However, if your water suffers from an overdose of calcium bicarbonate—if it is so-called "temporary hard water"—the problem can be easily solved. Just boil the water; then let it cool. When the water is boiled, calcium carbonate is formed, and being very insoluble, precipitates from the water, leaving it perfectly clean and without sediment to cause harm in your photographic developers.

Binder Canvases Can Be Kept Safely in Roof of Barn

TO KEEP binder canvases from being damaged by mice, I take a piece of hay wire about 3′ long and staple both ends to the 2 by 4 in the peak of the roof, then insert the canvas in the sling formed by the wire. There is room for the canvases from one binder if the wire ends are nailed about 1′ from the top of the roof. Be sure the nails are firmly in place.—JULIUS HOUDEK.



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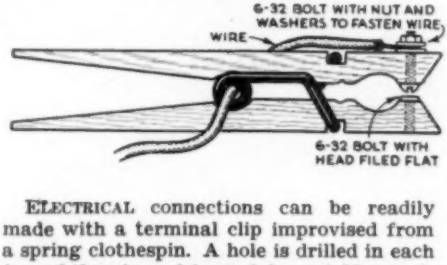
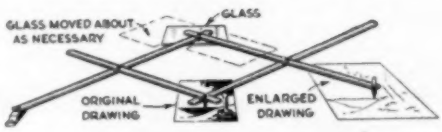
Terminal Clip Is Improvised from a Spring Clothespin



ELECTRICAL connections can be readily made with a terminal clip improvised from a spring clothespin. A hole is drilled in each jaw of the pin and tapped for a 6-32 round-head machine screw. Run the screws through the jaw from the inside, leaving one long enough to be used as a binding post. File the head of the other flat. Run the connecting wire through the coil of the spring, as shown in the drawing above. This will relieve any strain on the terminal connection and reduce the likelihood that the wire will pull loose.—CHARLES HOLT.

Glass Sheet Reduces Friction In Pantograph Drawing



A PANTOGRAPH can be made to operate more easily, especially when copying fine details, if a small sheet of glass is placed under the metal rest as shown above. If the glass is too small to cover the entire movement of the rest, it can be moved about as the drawing progresses. In this manner, enlarging or reducing work can be done much faster.—E. G. MACHAUER.

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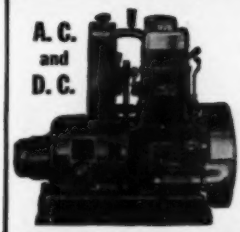

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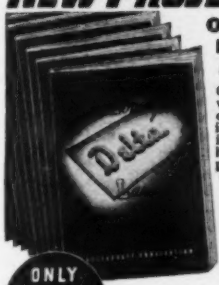

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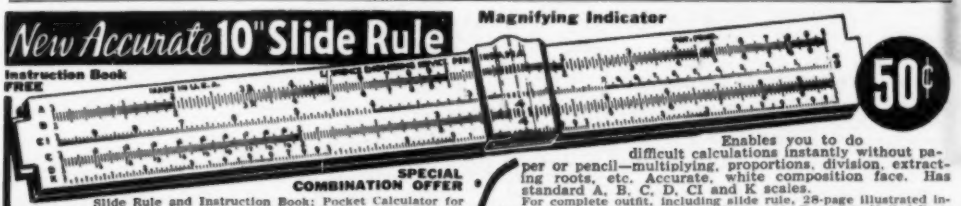

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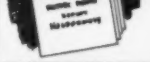

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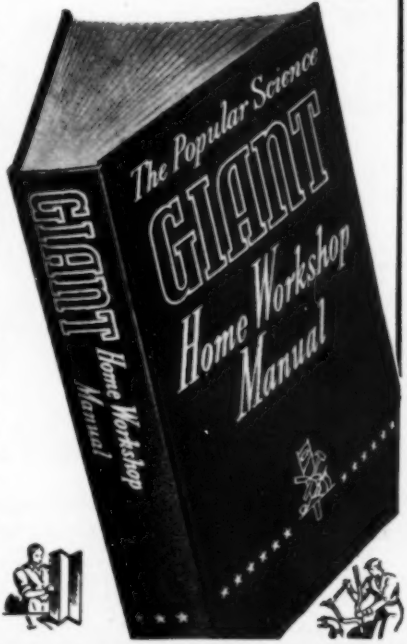

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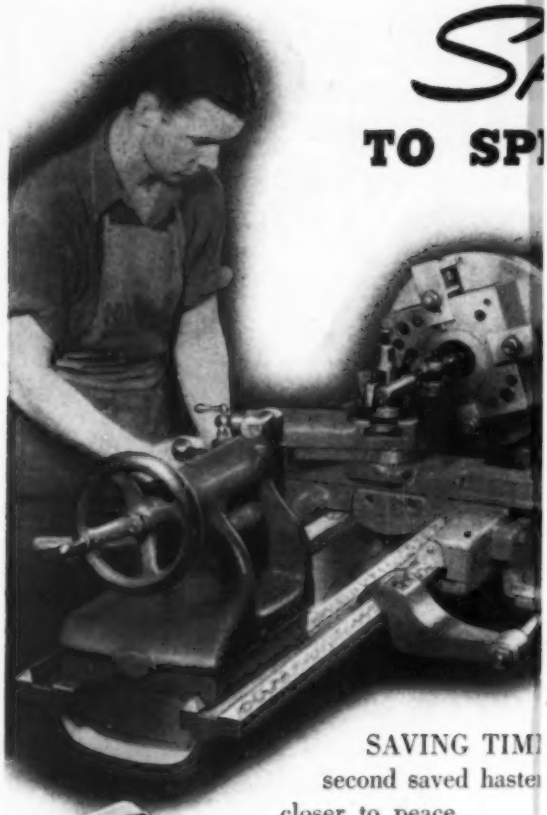

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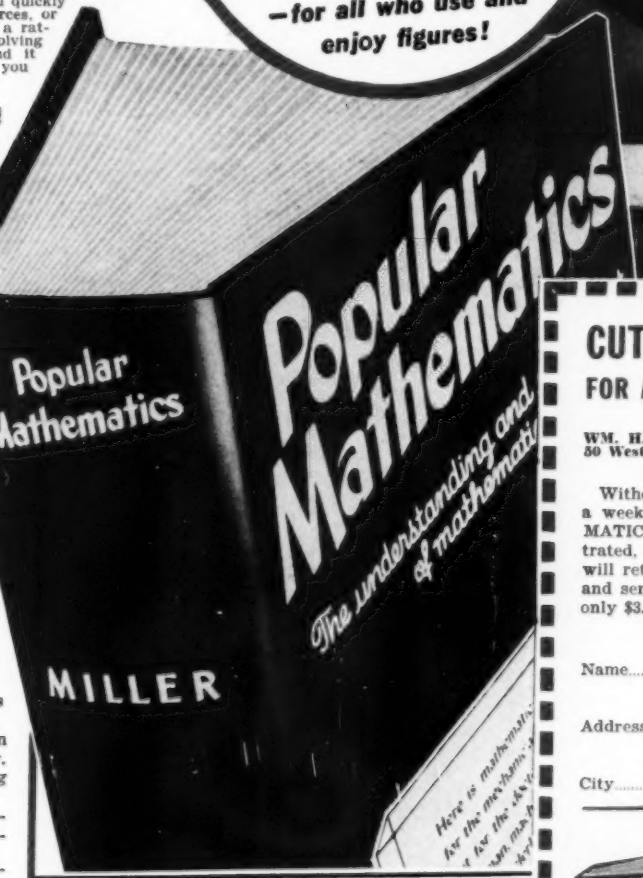

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